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A SECOND DIGEST OF THE LITERATURE ON DDT  
(May 1, 1944, to December 31, 1944)

By

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The first digest of the literature on DDT (E-631) was based on the first list of publications on DDT from 1874 through April 30, 1944. Similarly, this second digest is based on the second list of publications on DDT (E-660), which brought the bibliography of this subject up to January 1, 1945.

#### DEFINITIONS

"DDT" means the chemical 2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane.--U. S. War Production Board (396).

The contraction "DDT" was devised by an official of the [British] Ministry of Supply early in 1943 for the substance alpha, alpha'-dichlorodiphenyl-beta, beta, beta-trichloroethane.--West and Campbell (406).

"DDT" is a term coined to designate briefly the substance dichlorodiphenyl-trichloroethane, and the term "pure DDT" designates para,para'-dichloro-diphenyl-trichloroethane, which is the most active isomer.--Munro (327).

Gesarol is a proprietary generic term for a series of insecticidal compositions of DDT for use against agricultural pests. Gesarex is a DDT composition containing compatible fungicides. Gesapon is a formulation containing DDT in a form assuring penetration of the soil sufficient to reach the pests.--Geigy Co. (255).

Neocid - A proprietary generic term for a series of insecticidal compositions of DDT for use against insects affecting man and animal.--Geigy Co. (256).

Information concerning GNB-A-DDT- the active ingredient of Neocids and Gesarols was published by the Geigy Company, Inc., in July 1944 (257) and again in December 1944 (165).

Information on De De Tane (a proprietary insecticide containing DDT) was published by the Murphy Chemical Company, Ltd., (328) and by Chambers, Hey, and Smitt (208).

#### EARLY HISTORY OF DDT

As early as September 1941 Geigy, of Switzerland, reported that Gesarol dust containing as little as 1 percent of DDT repeatedly had given good protection against the Colorado potato beetle.--Geigy Co. (255).

When the United States entered the war, it became manifest that its uniformed men would be sent to all parts of the world, meeting the menace of typhus and other dread diseases in many infected areas. Geigy in Basle, aware it had the most effective enemy of typhus ever experienced

in medical history, informed Major DeJonge, American military attache in Berne, in August 1942, that Neocid, the lousicidal composition of DDT, had proved amazingly effective against the typhus-carrying louse, and that it possessed incredible residual potency, an all important factor. Geigy simultaneously notified its New York subsidiary of its significant discovery. Contrary to a false published story that a quantity was smuggled out of Switzerland, it was sent openly from Basle, as a regular transaction between the two divisions of the chemical firm. Another false story, that Geigy was unaware of the lousicidal properties of the composition, is refuted by the fact that Geigy not only discovered its lousicidal properties but brought them to the attention of the United States Government in 1942.--Geigy Co. (258).

In 1942 the J. R. Geigy Company drew the attention of the British legation to the importance which they attached to their discovery of DDT, and the British Geigy Company in Manchester brought the compound to the notice of the authorities here. The early tests were extremely promising, and quickly confirmed the observation of Wiesmann of the efficacy of DDT against lice. Almost immediately teams were formed of Government, university, and industrial research workers, and the many aspects which required investigation before adoption of a product for the armed forces were investigated. Simultaneously pilot-plant production, based on the J. R. Geigy experience, was started so that difficulties associated with larger scale production could be anticipated.--Campbell and West (199); also Anon. (75, 104). Then the collaboration was extended to include workers in the United States and in the Dominions.--Campbell and West (198).

Gesarol Spritzmittel, the original Geigy formulation of DDT for spraying purposes, was advertised as early as March 14, 1942, in the Swiss journal Schweizerische Zeitschrift für Obst und Weinbau. This advertisement called attention to the product as an arsenic-free organic stomach and contact insecticide, stable to light and air, and useful for the control of the Colorado potato beetle and several other insects. The product was stated to be nonpoisonous to man and bees. --J. R. Geigy, A. G. (250). Gesarol Spritzmittel and Gesarol Staubbemittel (a DDT dust) were also advertised in later issues of this journal (251, 252, 253); also Gesarex (251) on March 27, 1943.

The scramble for publicity in the attempts to hitch on to the tail of the sensational DDT kite is the subject of an editorial in Soap and Sanitary Chemicals.--Anon. (148).

#### CHEMISTRY

##### Synthesis

The preparation of DDT according to Zeidler's procedure is described. The product crystallized from ethanol had a m.p. of 107° C. --Colorado and Leyve (211).

The preparation of crude DDT (initial softening point about 75° C.) in 7-pound lots is described. The materials were chloral hydrate U.S.P. grade, chlorobenzene commercial grade, and c.p. sulfuric acid (96 per cent), and the main reaction was carried out in 22-liter round-bottom flasks equipped with stainless steel stirrers.--Breckenridge (189).

#### Manufacture

The Brothman continuous process for DDT production is described.

Chloral is produced by: (1) Direct chlorination of alcohol in the presence of ferric chloride catalyst to form chloral alcoholate; (2) Liberation of chloral from chloral alcoholate by water dilution and by sulfuric acid acidulation treatment; (3) Separation by fractionation of chloral from side products formed during the chlorination and acidulation steps; (4) Recovery of byproduct hydrogen chloride and excess chlorine as hydrochloric acid and as sodium hypochlorite.

DDT is produced by: (1) Reaction of chloral and chlorobenzene with oleum to form dichlorodiphenyl-trichloroethane, its isomers and polymers; (2) Separation and neutralization of the dissolved DDT from oleum by settling, then by water and alkaline washings; (3) Vacuum distillation and recovery of chlorobenzene solvent, followed by air stripping of residual chlorobenzene from DDT; (4) Cooling and solidification of DDT, followed by pulverizing, blending with extenders, and final packaging. Basic economies of the Brothman continuous processes show up best in estimated manufacturing cost figures for the final product. Of the estimated net cost of considerably less than \$0.30 per pound for DDT, raw materials alone account for almost 75 percent, while steam, water, electrical energy, and labor amount to only about 8 percent. Overhead accounts for some 17 percent of the total cost.--Callaham (193).

#### Solubility

DDT is a white powder with a very faint fruity odor, and it is practically insoluble in water. It is, however, very soluble in cyclohexanone, benzene, toluene, and xylene. It can be dissolved also in petroleum oils, being much more easily dissolved in olefin and cyclic hydrocarbons than in paraffins.--West and Campbell (406).

Soluble in acetone, kerosene, petroleum distillate, alcohols, Cellosolve (ethylene glycol monoethyl ether), and ethyl alcohol.--Herms and Gray (276).

Soluble in alcohol, kerosene, and other organic solvents.--Anon. (3).

Solvents include chlorobenzene, naphthalene, nitrobenzene, 1-chloronaphthalene, stearic acid, *n*-octadecyl alcohol, and petroleum fractions (b.p. over 100).--Fleck and Haller (244).

DDT is soluble in acetone, ether, hot alcohol, cyclohexanone, dimethyl phthalate, and olive oil.--Smith and Stohlman (371).

### Solubility of DDT

(Grams per 100 grams of solvent at ordinary temperatures)

Benzene	106	Petroleum ether, b.p. 100-120° C.	10
Sextone (cyclohexanone)	100	Cyclohexanol	8
Chloroform	96	n-Butyl alcohol	8
Ethyl acetate	68	Petroleum ether, b.p. 40-60° C.	6
Tetrachloroethane	56	Orchard and spray oil	5
Tetralin	52	Liquid paraffin	4
Toluene	48	tert-Butyl alcohol	4
Ether	45	Ethanol (99.5 percent)	4
Kerosene (vaporizing)	11		

--Campbell and West (196, 199, 200, 202); Callaham (193).

### Stability

Anhydrous ferric and aluminum chlorides, iron, iron oxides, and certain mineral materials have been found to act catalytically to eliminate hydrogen chloride from certain alpha-trichloro-beta-disubstituted ethanes, including DDT, to form the corresponding alpha-dichloro-beta-disubstituted ethylenes. This catalytic action may be inhibited by some solvents and promoted by others. This reaction was found to proceed at an even lower temperature when a solution in chlorobenzene, naphthalene, nitrobenzene, or 1-chloronaphthalene was used. On the other hand, solvents such as stearic acid, n-octadecyl alcohol, and petroleum fractions (b.p. over 100°) inhibited the reaction. Aluminum chloride is the most active catalyst. As little as 0.01 percent of anhydrous ferric chloride will catalyze this reaction. Fuller's earth and some mineral products show catalytic activity probably due to the presence of small amounts of iron compounds.--Fleck and Haller (244).

In a study of the reaction of alcoholic potash on 1,1-diaryl-2,2,2-tri-chloroethanes, compounds in which the aryl radicals were phenyl, 4-tolyl, 4-anisyl, 4-phenetyl, 2,4 and 2,5-xylyl split off hydrochloric acid in this reaction, forming the corresponding dichloroethylene derivative.--Brand and Bussee-Sundermann (187).

### Relation between chemical constitution and insecticidal action of DDT

A contact poison to be effective should have a toxic component and a lipoid-soluble component. In the case of DDT the "condensed" chlorobenzene system is the first component and the trichloromethyl (chloroform) radical is the second. Besides chloroform, cyclopropane, ethylene, and divinyl ether possess high lipoid solubility. We can therefore expect to get good contact poisons by hooking these components to the toxicant.--Lauger *et al.* (298).

The ethylene compound formed when DDT loses hydrochloric acid, p,p'-dichlorobenzophenone, and bis(p-chlorophenyl)acetic acid are almost inactive both as contact and stomach insecticides, indicating that the HC-CCl<sub>3</sub> group is associated with insecticidal activity. The toxicity of DDT is attributed to this grouping plus high lipid solubility conferred by the chlorophenyl groups.--Martin and Wain (320).

### Volatility

A glass plate was dusted with 325-mesh DDT (m.p. 107°-108° C.) until 1.2672 mg. per square centimeter had been deposited, then kept at 45° C. in an air current of 10 liters per hour. At the end of 37 days 4.22 mg. had evaporated, indicating a life of about 18 months. --Fleck (243).

### Analysis

A modification of Winter's method for the determination of halogen in organic compounds has been adapted to the determination of DDT. About 1 hour is required for an analysis, and the method is sufficiently sensitive for the determination of DDT spray residues. The sample to be analyzed is volatilized and burned in a flame of ordinary illuminating gas, the chlorine-containing combustion products are absorbed in an alkaline solution of sodium arsenite, and this solution is then titrated for chloride ion using standard solutions of silver nitrate and ammonium thiocyanate. A suitable apparatus is described.--Hall *et al.* (270).

The addition of methanolic sodium methylate to a benzene solution of tetranitro-p,p'-DDT (m.p. 223.5°-224.5°) gives a blue color with one absorption maximum and one minimum. The tetranitro o,p'-DDT (m.p. 229.5°-230°) yields a violet-red color with two maxima and two minima. A colorimetric method for the determination of DDT making use of these reactions has been developed.--Schechter and Haller (358).

DDT was estimated by determining total chlorine by refluxing in absolute alcohol with metallic sodium and titrating the sodium chloride by the Volhard method.--Smith and Stohlman (371).

A method for the quantitative estimation of DDT based on its dehydrochlorination with N alcoholic potassium hydroxide is described. DDT on fruit or leaves is removed with benzene, the solution filtered and evaporated to dryness, the residue refluxed with 50 ml. of normal alcoholic potassium hydroxide solution, the solution acidified with nitric acid, nitrobenzene and an excess of N/10 silver nitrate solution added and the excess silver titrated with N/10 potassium thiocyanate solution with ferric nitrate as an indicator.--Gunther (267).

Attention is called to certain changes in this procedure, especially the precaution that the benzene solution of DDT be evaporated only nearly to dryness and that the temperature of the residue not be allowed to exceed 85° C. (instead of 105°). It is stated, "It has been brought to our attention that commercial or technical DDT may contain, in addition to the p,p'-isomer (DDT) quantities of the o,p'-isomer. This latter isomer, it has been reported, may liberate more than one molecule of HCl per parent molecule, under our experimental conditions, in contrast to the behavior of the p,p'-isomer (DDT). This behavior has not yet been verified, but we wish to bring it to your attention as a possibility to be kept in mind. If it is correct, then commercial or technical DDT would analyze high with our method."--Gunther (267).

### Specifications

The United States War and Navy Departments (394), on June 30, 1944, issued joint specifications on DDT. "DDT shall be a technical grade of 2,2-bis-(p-chlorophenyl)-1,1,1-trichloroethane, free from added modifying agents, diluents or adulterants." The chemical and physical properties shall conform to the following requirements:

	<u>Minimum</u>	<u>Maximum</u>
Ash content, percent by weight	--	0.5
Setting point, °C.	88.0	--
Organically bound chlorine, percent by weight	48.0	51.0
pH of aqueous extract	5.0	8.0
Water-insoluble, steam-volatile material ml. per gram	--	0.005
Chloral hydrate, percent by weight	--	0.020
Water-soluble material, percent by weight	--	0.25

### Compounds closely related to DDT

The reaction of chloral and toluene to produce 1-trichloro-2,2-bis(p-tolyl)ethane, m.p. 89°, was reported in 1874.--Fischer (242).

Radioactive bromine was used to prepare dibromodiphenyltrichloroethane, m.p. 139.0°-139.5°.--Hansen et al. (273)

The following compounds were prepared and tested for insecticidal value:

### Melting Point, °C.

1-trichloro-2,2-diphenylethane	60-62
1-trichloro-2,2-bis(hydroxyphenyl)ethane	202
1-trichloro-2,2-bis(hydroxyphenyl)ethane diacetate	140
1-trichloro-2,2-bis( <u>p</u> -chlorophenyl)ethane [ <u>p,p'</u> -DDT]	107
1-dichloro-2,2-bis( <u>p</u> -chlorophenyl)ethylene	88
1-trichloro-2,2-bis(1-hydroxynaphthyl)ethane	174-176
p,p'-dichlorobenzophenone	143-144
1-trichloro-2,2-anhydribis(2-hydroxynaphthyl)ethane	242-243
Metachloral	
Chloretone	80-81

See also Siegler and Gertler (365) under Carpocapsa pomonella.--Martin et al. (319).

Miscellaneous

DDT chemical investigations sponsored by the Office of Scientific Research and Development were conducted at Harvard University, Maryland University, and Ohio State University.--(35, 38).

PHARMACOLOGY

DDT was tested on dogs, cats, house rats, white mice, pigeons, chickens, toads, and fish.

- a) Dogs. Five grams of a 5 percent DDT mixture was mixed into the daily ration of two dogs of 5 to 6 kg. body weight for 31 days. During this entire time the dogs showed no general signs of any poisoning.
- b) Cats. Four cats were subjected to a treatment of DDT in different doses; two received six single doses and the other two six doses in increasing fractions. Two cats received a total of 48 to 72 mg. intramuscularly and two received a total of 315 and 480 mg. by mouth. During the entire time of observation, which lasted 15 days, the cats showed no signs of toxic phenomena.
- c) Rats. Six house rats (Rattus norvegicus) weighing on an average 300 grams each during 6 consecutive days were given by mouth 1.2 grams of DDT suspended in a colloidal solution, in fractional doses of 0.2 gram. The rats remained active and normal for more than 6 months in their cages without showing any signs of poisoning or other disturbances in their normal condition.
- d) White mice. Four white mice, weighing 10 grams each, which had been raised in the laboratory, received 0.015 gram each of DDT in doses of 0.003 gram for 5 consecutive days. To two of these mice the DDT was administered intramuscularly and to the others by mouth. The two mice which received the chemical by injection lost weight from the 6th day and remained depressed in their cages, whereas the two remaining mice continued to be normal for 30 days of observation.
- e) Pigeons. During 5 days daily and increasing doses of DDT were given to a lot of pigeons in various ways. Three pigeons received totals of 24, 34, and 41 mg. intravenously, two received 24 and 34 mg. intramuscularly, and two received 36 and 50 mg. by mouth. The birds showed no sign of intoxication and lived in the cage normally for more than 3 months, when they were sacrificed.
- f) Chickens. Two chickens weighing 1000 grams each were subjected to a test with DDT. One of them received a total of 1 gram intravenously in fractional doses of 0.2 gram during 5 days; the other received twice as much by mouth during the same period of time. Both chickens remained a long time in their cages but showed no sign of poisoning.

The following tests were made on cold-blooded animals:

a) Batrachians: The water in a vivarium containing frogs (Leptodactylus ocellatus) and toads (Bufo marinus) was treated with 0.2 gram of DDT approaching a concentration of 1/12,500 in water. The batrachians stayed in this poisoned water 2 to 3 hours daily for 4 days, without it having any bad effect on them.

b) Fish. The water in two aquariums, in which there were 12 fish (Cyprinodontidae (Guarus)), Cichlidae (Acaras) and Characidae (Lambaris), was treated with DDT in the proportion of 1 gram per 20,000 liters of water. Twenty-six hours later all the fish were still acting normally and showed no signs of poisoning or asphyxia. After 27 to 30 hours 3 fish showed signs of asphyxia and succumbed 2 hours later. The remaining fish lived normally for more than 60 days. The water thus treated had no toxic effect upon 11 other small fish which were placed into it.

DDT was also tested on the skin and conjunctiva of guinea pigs. On two of them 5 percent of DDT in vaseline was applied and on two others a compress of cotton soaked in a 5 percent aqueous suspension of the chemical. After 24 hours no inflammation or the slightest local irritation to the skin was observed. Two dogs treated with a powder containing 5 percent of DDT and guinea pigs bathed in a 2 percent solution showed no skin irritation.

DDT was then applied to the writers' own skin and that of two helpers in the laboratory. Cotton wicks soaked in a concentrated solution as well as wicks containing undiluted DDT were placed (held fast with adhesive plaster) on the inner side of the lower arm. Twenty-four hours later the DDT caused no irritation, burning, or any other local or general reaction. The same result has been obtained in a group of individuals who were subjected to a rubbing of the groin with a 2 percent DDT ointment (against *rhinithirus pubis*).

An aqueous suspension containing 0.5 percent of DDT applied to the eyeballs of two rabbits did not produce the slightest irritation. --Wasicky and Unti (404).

Pure DDT and Gesarol P and Gesarol A (3 percent of DDT in each) were tested on rabbits, 1-month-old chickens, and hens. A rabbit fed a total of 2.64 grams of pure DDT over a period of 17 days gained about 10 percent in weight. Chickens ingesting 100 mg. of Gesarol A daily presented no abnormal symptoms and after 40 days showed no sign of toxication. Hens fed for 30 days on millet treated with Gesarol P (12 grams per 60-kg. bag) showed no signs of poisoning. One gram of pure DDT dissolved in castor oil was administered to a hen of 1.5 kg. weight, with no bad effect. --Lepage and Giannotti (297).

Single doses of DDT in olive oil incorporated in food pellets, when swallowed by 6- to 10-gram goldfish, were lethal in amounts ranging from 63 to 200 mg. per kilogram. Within this range the total mortality was approximately 55 percent, the number of deaths being correlated roughly with the size of the dose. Death followed these single ingestions of DDT in 24 hours to 6 1/2 days, the onset of the symptoms of poisoning being delayed in some cases for more than 4 days. The fish became hyperirritable at first and subsequently developed muscular incoordination, muscular spasms, and finally marked prostration, which in some cases persisted for 3 days or more before death. The gross picture of the DDT poisoning resembled that produced by phenol or picrotoxin. All frogs receiving DDT dissolved in olive oil, by injections into the dorsal lymph sac, were killed in 4 to 72 hours by single doses of 150 mg. per kilogram. Some frogs died following injection of as little as 10 mg. per kilogram. --  
Ellis et al. (234); abstracted by Anon. (155).

On the estate of the Swiss Federal Agricultural Institute at Berne-Liebefeld green fodder was treated with a suspension of Gesarol in water (10 to 100 pounds per 100 imperial gallons) and fed to sheep. In all test groups the increase in weight was entirely normal, and no symptoms of any detrimental effect due to the treatment of the fodder were evident. The test was later repeated with cows; the volume and quality of the milk, the process of calving, and the soundness and growth of the calves fed the milk of these cows were in all cases normal. --West and Campbell (406).

Applications of DDT in oil to animals resulted in necroses of their livers. At the Bureau of Entomology and Plant Quarantine laboratory in Orlando, Fla., three men subjected for 6 months to heavy dosages in aerosol tests were examined to determine whether any injury had been done to their livers and no damage was found. Moderate doses were given to pregnant ewes and normal lambs were born, with no evidence of abortion. Several hundred goats were dipped in a DDT emulsion and examination of their eyes yielded no evidence that vision had been interfered with. --Anon. (150).

Clinton H. Thienes, of the University of Southern California, carried on a diet test with white rats using DDT. Two months after the rats were put on a diet containing 1 part of DDT in 10,000 parts of foodstuffs they began to have convulsions. Half of the rats were restored to normal food with near disappearance of convulsions, but both the withdrawn rats and those remaining on the DDT diet died within the next 3 days. In May 1944 the United States Bureau of Entomology and Plant Quarantine fenced in 3/4 acre of grassland containing grasshopper egg masses about 60 miles from San Diego, Calif., and when the hoppers were emerging, dusted the area with a dust containing 10-percent of DDT at the rate of 40 pounds per acre. After 48 hours the California Bureau of Chemistry put three ewe sheep in the field. After 72 hours they showed extreme neurologic symptoms. The animals eventually recovered, probably owing to removal of DDT dust from the vegetation by wind and rain. A month later the field was dusted again in like manner. The animals behaved in the same manner as with the first treatment, but again

all recovered. One of the ewes was taken to the University of Southern California, where 2 grams of DDT was administered orally daily for 11 days. No symptoms were noticeable and the dose was increased to 4 grams per day and continued for 40 days. Still no symptoms were noticeable and the dose was further increased to 8 grams daily, with no symptoms 2 weeks later. --Cox (216).

#### Investigations by the Food and Drug Administration

In solid form DDT applied topically to the skin of several species of animals was nonirritating, nonsensitizing, and not appreciably absorbed. In solution, either in oil or in organic solvent, it readily penetrated the skin, and was very mildly irritating and a very mild sensitizing agent. In single and multiple-dose administration (acute and subacute) there were wide individual as well as wide species variations. In prolonged feeding experiments (chronic toxicity) rats have been fed for about 18 months diets containing 100, 200, 400, and 800 p.p.m. of DDT. Other animals have been studied for shorter periods. The pharmacological manifestations of effect from DDT are principally loss of appetite, mild to severe tremors of central nervous system origin, convulsions, and death. Tremors can be prevented or abolished by general anesthetics and narcotics. Histopathologic examination of tissues of animals which have received DDT shows tissue damage but it is neither striking nor characteristic for all species (Report of talk by H. O. Calvery before Entomological Society of Washington). --[U. S.] Federal Security Agency (391); abstracted by Anon. (143).

(1) The application of powders containing 5 percent of DDT to the skin produced no evidence of systemic toxicity or of primary irritation; (2) Solutions of DDT in dimethyl phthalate are absorbed by both intact and abraded skin; (3) Solutions of DDT cause a mild but definite sensitization in the guinea pig; (4) the inunction of doses as low as 0.5 ml. of 30 percent solution of DDT per kgm./day (150 mgm./kgm./day of DDT) to rabbits, rats and guinea pigs may cause death in some cases after 30 days; (5) In the animal species tested there were wide individual variations in susceptibility; (6) affected animals exhibited anorexia, severe weight loss, hyperexcitability, nervous tremors leading to clonic convulsions. Emaciated animals became easy prey to secondary infections; (7) severely poisoned animals exhibited a moderate leucocytosis with a characteristic increase in the percentage of heterophiles; (8) the above data indicate that the unlimited use of DDT solutions on the skin is not free of danger; however, some solutions of DDT have been found safe for restricted use. --Draize et al. (229).

Feeding experiments show that small amounts of DDT in the diet will produce toxicity in experimental animals, and that the safe chronic level would be very low indeed. Experiments on several species of animals extending over periods longer than 50 weeks will be necessary before the chronic toxicity of this compound can be adequately assessed. --Draize et al. (230); abstracted by Anon. (136).

DDT is acutely toxic when fed to small laboratory animals in doses from 150 to 750 mg. per kilogram. Acute doses may produce anorexia, tremors, depression, and death. DDT is capable of causing subacute toxicity when given in small amounts in the diet for periods of 3 days to 20 weeks. Definite signs of toxicity are produced by levels in the diet of 0.05 percent for rats and mice, 0.1 percent for guinea pigs, and less than 0.05 percent for growing chicks. Characteristic of DDT poisoning is the wide variation in individual susceptibility, making the estimate of a safely tolerated dose extremely difficult.--Woodard et al. (417).

#### Investigations by the U. S. Public Health Service

Studies conducted at the National Institute of Health in Bethesda, Md., showed that DDT in concentrations up to 10 percent in inert powders, for dusting clothes, as in the extermination of lice, offers no serious health consequences. The use of a 1 percent DDT-Deobase mist mixture had no toxic effect on rabbits, and it should be safe to use as a fly spray. In a clinical and laboratory study of three men who had had several months of continuous occupational exposure to DDT in its various forms as an insecticide, no definite toxic effects from exposure to DDT were indicated. Inhalation studies of the toxicity and potential dangers of aerosols, dusting powders, and mists containing DDT on mice, rats, guinea pigs, dogs, monkeys, and human beings, revealed a marked difference in the susceptibility of different animal species. Mice were more susceptible than rats. Only when relatively large doses were ingested or absorbed through the skin did toxic reactions set in, such as tremors, "jumpiness" as in strychnine poisoning, convulsions with death, fatty degeneration of the liver and kidneys, or changes in the nerve structure. In experiments with dogs daily insufflation of 100 mg. of pure DDT per kilogram of body weight caused definite signs of poisoning in only one out of the three animals tested, after a period of 18 days. Although this study deals only with the appraisal of the potential dangers of DDT when inhaled as an aerosol, dust, or mist, Dr. Neal pointed out that massive doses whether by mouth or by skin absorption will cause toxic reactions. Heavy contamination of foods should be avoided. The use of DDT in 1 to 5 percent solutions with 10 percent of cyclohexanone in 85 to 95 percent of Freon, as aerosol, should offer no serious health hazards when used as an insecticide. (Report of talk by Paul A. Neal before Entomological Society of Washington.)--[U. S.] Federal Security Agency (392).

Because a 1-percent DDT-Deobase mixture was found to be nontoxic to rabbits exposed for 48 minutes daily over a period of 4 weeks, it is believed that its use as a fly spray, which involves only temporary and comparatively moderate exposure to much lower concentrations, should be safe. However, irritation of the skin may occur following heavy exposure.--Neal et al. (329); abstracted by Anon. (138, 140, 170).

Microscopic study was made of 117 animals given DDT by inunction, by stomach tube, or by admixture in the diet and in doses varying from those fatal in a few days to those causing no perceptible lesions after several months. The animals examined comprise 16 rabbits, 38 rats, 24 guinea pigs, 14 mice, 12 chicks, 6 dogs, 3 cows, 3 sheep, and 1 horse. Although there were wide variations in sensitivity to the compound among the different individuals of a given species, the lesions caused were quite consistent throughout the different species. On the higher dosage levels with the animals surviving for 1 to several weeks, there was typically caused a moderate degree of central necrosis of the liver, or with the longer periods of survival a combination of central necrosis and reparative hypertrophy which can be labeled as a moderate subacute degeneration of the liver. The thyroid often showed moderated colloid depletion, less often epithelial desquamation, and rarely epithelial hyperplasia. Very slight to moderate focal necrosis of voluntary muscles occurred in about 20 percent of animals on the higher dosage levels. Rabbits showed certain lesions not seen in the other species, a focal necrosis of the gall bladder, and an increased incidence of the "spontaneous" types of encephalitis and nephritis. Dermatitis in inuncted animals was mild except that rabbits on the highest doses showed slight focal necrosis of the epidermis. For a given dosage level of DDT, chickens and guinea pigs showed fewer histological lesions than did the other species. A special effort was made to determine nerve-cell changes in the brain and spinal cord of animals with tremors. With routine fixation and staining (formalin and Orth's; hematoxylin-eosin) no changes could be seen that were not present in controls similarly and concurrently fixed and stained. Rare myocardial and adrenal lesions may be of significance. DDT caused no or insignificant effects on bone marrow, bone, testis, pancreas, and spleen. Renal lesions were slight and infrequent. Because of the tremors of long duration produced by it, DDT would appear to be a promising experimental agent for the neuro-physiologist.--Nelson et al. (330); abstracted by Anon. (66, 70, 71, 77, 110, 138).

Material from 5 cats, 41 rabbits, and 34 rats was submitted for histologic study. In spite of the pronounced neurologic symptoms, histologic alterations in the central nervous system have been relatively slight. Vacuolation around large nerve cells in cord and cerebral motor nuclei has been seen in cats, rats, and rabbits; tigrolysis and cell vacuolation in cats and rats. The most striking pathologic alterations are seen in the liver. Here there is a hyaline degeneration similar to that described in poisoning by azobenzene and some of its derivatives. Hyaline oxyphil masses are formed in the central part of the cytoplasm and then are surrounded by vacuoles. This change has been seen in rats and rabbits. Also a variable amount of fatty degeneration of liver cells, often centrolobular, is observed in cats, rats, and rabbits. Midzonal and centrolobular areas of coagulation necrosis are found in these animals, which in rats and rabbits is accompanied by an interstitial and peripheral proliferative

reaction leading to replacement by a new vascular granulation tissue. With more extensive and confluent necrosis this replacement process leads to trabeculation. Finally there is seen also a focal hydropic degeneration of liver cells in rats and rabbits in which the affected cells may reach two or three times their normal diameter. Muscle necrosis with proliferative reaction was seen in one of the rabbits. --Lillie and Smith (304).

The acute and chronic toxicity, the cumulative action and absorbability from the skin of DDT in experimental animals are described. DDT has been found in the urine, bile, blood, liver, kidney, and central nervous system in experimental poisoning with the substance.--Smith and Stohlman (371); abstracted by Anon. (110, 132).

#### Protection of workmen handling DDT

In four plants in New Jersey blending DDT with talc for the preparation of the Army's louse powder the following measures for the protection of the workers' health were put into effect: (1) Complete enclosure of the entire production line is insisted upon; (2) no lunches are eaten in the production area; (3) strictest personal hygiene is practiced. This includes complete washing of all exposed parts of the body prior to lunch time, and before going home in the afternoon; (4) local exhaust ventilation apparatus is installed at all locations where the dust might be liberated into the workroom air; and (5) a completely laundered set of work clothes is provided daily for all the employees.--Radcliffe (345).

#### EFFECT OF DDT ON PLANTS

In greenhouse tests, DDT at the rate of 2 pounds per 100 imperial gallons of water caused no apparent damage to raspberry, gooseberry, currant, potato, apple, or pear. In one test 10 pounds of DDT per 100 gallons caused no apparent injury to calendula, rose, chrysanthemum, bean, cucumber, or snapdragon. Velsicol AR-60 proved to be an excellent solvent and carrier for DDT, and solutions containing 20 grams of DDT and 10 cc. of Triton X-100 in Velsicol to make 100 cc. gave no plant injury when diluted 1-400 with water. However, such solutions diluted 1-200 and 1-100 resulted in burned spots on apple, snapdragon, and some other foliage. Tests using the Velsicol without the DDT indicated that the injury was probably due entirely to the oil. A 20-percent solution of DDT in acetone caused slight injury when diluted 1-200 and 1-100 with water but not nearly so pronounced as the Velsicol solutions.--Ross (354).

On the basis of one year of field experience it is concluded that DDT can be safely used on potatoes.--Granovsky (263, 264).

DDT (4 pounds of 25-percent DDT) was used on apple trees in one or more sprays with each of the following: Bordeaux mixture 2-4-100, lead arsenate 3 pounds, and DN-111 1 1/4 pounds. No injury was apparent on the fruit or foliage. No injury resulted from the applications of DDT and Fermate. An application of DDT and Tenn. copper No. 26 following an application of DDT and Fermate caused considerable injury to

apple foliage. Also, an application of DDT and Fermate following Bordeaux mixture and lead arsenate caused severe injury to apple foliage. It seems unsafe to apply Fermate just before or just after an application of a copper fungicide.--Hough (284).

Talc dust containing 3 percent of DDT (Gesarol AX dust) caused some injury to green bean plants in Hawaii when the plants were wet when dusted and the application was heavy. None has been observed with a 2- or 1-percent dust or with sprays of 2 and 1 pound of DDT per 100 gallons. These sprays were prepared from Gesarol AKD 20 spray containing 20 percent active agent together with a wetting agent.--Holdaway and Nishida (281).

Gesarol dust preparations have no phytocidal action, nor have the Gesarol aqueous spray preparations when used in 1 or 2 percent suspension [10 or 20 pounds per 100 imperial gallons of water], but the sprays at 3 to 4 percent do sometimes cause scorching of foliage, and 4 percent showed marked scorching in both apple and pear foliage. As the 1 and 2 percent suspensions are generally effective against most insects, the scorching with the higher suspensions is less important. Many of the solvents used have themselves a marked phytocidal action.--West and Campbell (406).

Millet to which Gesarol P (3 percent of DDT) was added in the ratio of 1:1000 by weight (5 times the recommended dosage for weevil control) germinated almost as well as untreated millet.--Lepage and Giannotti (297). [Incorrectly Lepage in literature list.]

#### DDT SPRAY RESIDUE

Four applications of DDT (1.5 pounds per 100 gallons of water) made on July 5, 14, 25, and Aug. 5 left a residue of 0.049 grain DDT per pound of apples picked Sept. 2. Five applications of DDT (1 pound per 100 gallons of water) made on June 7, 20, July 10, 24, and Aug. 8, left a residue of 0.042 grain DDT per pound of apples whether picked Sept. 2 or Oct. 6. Apples from the second plot were treated for DDT residue removal, with results as follows:

	Grain per pound
Brushed (Trescott machine)	0.041
Washed 45 sec., hydrochloric acid 1.3 percent	.037
Washed 45 sec., sodium silicate 75 lb. and soap 1 lb.	.027
Washed 45 sec., trisodium phosphate 10 lb.	.032

--Hough (284).

DDT sprayed on fruit is difficult to wash off.--Anon. (86, 94).

De De Tane and a proprietary DDT emulsion gave control of the tomato moth caterpillar equal, if not superior, to that given by lead arsenate. The emulsion leaves no visible deposit, thus obviating the necessity for wiping the fruit.--Chambers, Hey, and Smitt (208).

#### FUNGI CIDAL VALUE

Agar plate tests were made in the laboratory with the fungi Ophiobolus graminis Sacc., Colletotrichum trifolii Bain and Essary, Pleospora herbarum Pers., Ascochyta imperfecta Peck, and Pseudoplea trifolii (Rostr) Petr. The DDT was placed on the agar in a 1-percent solution in alcohol. All fungi grew impartially over all the plates. Seeds of commercial Greenfeast peas were treated with DDT-kaolin dusts at the rate of 2 ounces per bushel. These dusts contained 0.1, 1, 5, and 50 percent of DDT. The seeds were planted in soil heavily infested with unspecified damping-off organisms, and after 14 days the emergence of the DDT-treated seeds was 0 to 1 percent and that of untreated seeds 0 percent whereas the emergence of Spergon-treated seeds was 86.5 percent. Even undiluted DDT was ineffective in preventing infection of wheat with flag smut, Urocystis tritici Koern.--Norris (331).

In addition to its insecticidal value DDT apparently has a considerable fungicidal value as well, for the early and late blight of potatoes was not so prevalent in the plots dusted with 5 percent of DDT as in plots treated with some common fungicides ordinarily used in the potato fields.--Granovsky (263, 264).

When applied to late-planted Dakota Red potatoes DDT (3/4 pound per 100 gallons), alone and in combination with copper oxychloride or zinc dimethyl dithiocarbamate, had no effect on control of early blight (Alternaria solani) but the plants were taller, broader, darker green in color, and had larger leaflets; also, the leaflets were flatter (less cupped) than when untreated or when the fungicides were used alone. --Heuberger and Wolfenbarger (277); also Anon. (160).

#### EFFECT ON WILDLIFE

The high toxicity of DDT to beneficial insects and to fish has caused considerable concern among nature lovers and fishermen.--Conant (213).

DDT is harmless to wild life in the areas sprayed, neither birds, animals, nor fish being affected by it.--Anon. (39, 53, 57, 74, 134).

In limited feeding and dusting tests conducted in the laboratory DDT was found to be only slightly toxic to the common brown snail of California.--California Fruit Growers Exchange (192).

#### PRODUCERS

##### United States:

In October 1944 present and prospective producers of DDT were listed as follows:

Present Commercial Producers

Cincinnati Chemical Works . . . . .	Norwood, Ohio
E. I. du Pont de Nemours and Co. . . . .	Grasselli, N. J.
Merck and Co., Inc. . . . .	Rahway, N. J.
Hercules Powder Co. . . . .	Parlin, N. J.
General Chemical Co. . . . .	Marcus Hook, Pa.
Monsanto Chemical Co. . . . .	St. Louis, Mo.
Elko Chemical Works, Inc. . . . .	Clinton, N. J.
J. T. Baker Chemical Co. . . . .	Phillipsburg, N. J.
Sherwin-Williams Co. . . . .	Cleveland, Ohio
American Home Products Co. . . . .	Marietta, Ohio

Prospective Producers

Pennsylvania Salt Manufacturing Co. . . . .	Philadelphia, Pa.
Michigan Chemical Co. . . . .	St. Louis, Mich.
Pharma Chemicals Corp. . . . .	New York, N. Y.

--Callaham (193).

For the first 8 months of the production program, until early in 1944, the Cincinnati Chemical Works, Norwood, Ohio, was the sole commercial producer of DDT in this country. From September 1943 to June 1944, this company increased its production sixfold. By this time it had made approximately 325 tons of DDT, enough to protect over 50 million soldiers against typhus for a month.--Callaham (193). See also Anon. (5, 16, 24, 32, 45, 54, 69, 96, 144); Peaker (340).

A dozen manufacturers are making DDT under wartime production licenses issued by Geigy, but only Du Pont has a license certain to carry over into the peace era.--Anon. (99).

Du Pont's Grasselli Chemicals Division is licensed by Geigy and Co. to manufacture and sell DDT. Construction of a new half-million-dollar plant was announced January 20, 1944. The Army recently flew the first 500-pound cargo produced at a Du Pont pilot plant to an overseas front.--Anon. (5, 9, 11, 12, 13, 16). See also (10, 45, 54, 69, 96, 144, 340).

In February 1944 Merck and Co. revealed that it was expanding its facilities for large-scale production of DDT at Government request.--Anon. (5, 7, 16). In July 1944 this company was stated to be in large-scale production.--Anon. (69). See also Anon. (45, 54, 96, 144); Peaker (340).

At the Parlin, N. J., plant of the Hercules Powder Company equipment for the manufacture of military explosives is being converted to make DDT with production expected to begin in May 1944.--Anon. (7, 14, 16). See also 45, 54, 69, 96, 144; Peaker (340).

Information on the production of DDT by other companies will be found in the following references:

General Chemical Co.--Anon. (54, 144); Peaker 340.

Monsanto Chemical Co.--Anon. (45, 54, 69, 82, 89, 96, 109, 141); Peaker (340).

Elko Chemical Works Inc.--Anon. (45, 54, 69, 96); Peaker 340.

J. T. Baker Chemical Co.--Anon. (45, 54, 96, 101); Peaker (340).

Sherwin-Williams Co.--Anon. (54, 144); Peaker (340).

American Home Products Co.--Anon. (54, 119, 122, 144); Peaker 340.

Pennsylvania Salt Manufacturing Co.--Anon. (54, 119, 144); Peaker 340.

Michigan Chemical Co.--Anon. (54, 119, 144, 168); Peaker 340.

Pharma Chemicals Co.--Anon. (54, 119, 144).

The Dow Chemical Co. and Rohm and Haas are mentioned as planning tentative production of DDT.--Peaker (340).

McCormick and Co., at Baltimore, Md., processes four DDT products--a residual spray, which is used in controlling bedbugs and flies in army camps, a delousing spray for use on prisoners of war, a delousing powder for service men, and a larvicide dust to be employed against mosquitoes.--Anon. (149).

Production problems are being worked out at Pennsylvania State College and Rhode Island State College under the Office of Production and Research Development of the War Production Board.--Anon. (35, 38).

The War Production Board in June 1944 set up a DDT Producers Industry Advisory Committee with the following membership: Fred Marsiglio, Merck and Co.; Fred Benner, Monsanto Chemical Co.; Oskar Frey, Cincinnati Chemical Works; Paul Mayfield, Hercules Powder Co.; T. H. McCormack, E. I. du Pont de Nemours and Co., Inc.; and Lee Kolker, Elk Chemical Works.--Agricultural Insecticide and Fungicide Association (173).

#### Brazil:

DDT is not at present manufactured in Brazil, but a number of products containing from 5 to 10 percent of this material will be marketed there. They will include powders and liquids for various agricultural and household uses as well as those against specific pests such as mosquitoes and fleas.--Anon. (146); Leslie (300, 301); Dean (223).

#### England:

The British patent rights were established in 1939. Following evidence that the material was a welcome substitute for pyrethrum and derris, scarce under war conditions, research started here and in the United States; and bulk production was entered upon by the Geigy Colour Company, Manchester, which took steps to introduce it

to the chief testing stations, both agricultural and medical, in the United Kingdom.--Anon. (117).

In October 1944 it was announced that DDT was being produced in the British Isles.--Anon. (116).

In England DDT was manufactured on a pilot-plant scale in April 1943, and bulk production started shortly after. Progress has been running parallel to that in the United States, and at no time has the one been very far ahead of the other. There has been a free exchange of information between all concerned.--West and Campbell (406).

#### Sweden

A Swedish branch of Geigy Company has been established in Norrkoping.--Jarl (287).

#### Production statistics

In August 1944 the DDT production program was reported to be well ahead of schedule with a rate of production in the neighborhood of 750,000 pounds per month, and with every prospect that the War Production Board goal of 1,900,000 pounds per month would be reached by the first of 1945. Only a little over a year ago the rate of output was but 1,000 pounds per month. Production was expected to reach 1,500,000 pounds per month during September 1944.--Peaker (340).

In November 1944 DDT production reached 2,000,000 pounds per month.--Peaker (340).

DDT production, according to George W. Fiero, of the War Production Board, has sky-rocketed from less than 60,000 pounds in January 1944 to approximately 2,000,000 pounds per month in December 1944.--Anon. (157); also Stenerson (378).

The monthly production of DDT in this country totaled about 0.5 ton the middle of 1943, increased to 150 tons by June 1944, at which time the Nation's accumulative production did not exceed 600 tons. Then, rising sharply, the monthly rate went up to the neighborhood of 400 tons by August, and 750 tons in September. The WPB goal of 950 to 1,000 tons a month is expected to be reached by 1945. If used only as a delousing dust, this monthly goal would be sufficient to protect over 150 million persons.--Callaham (193).

#### ALLOCATION

#### United States:

On June 15, 1944, allocation control was shifted from M-340 to M-300 by the War Production Board (396). This order--Part 3293 Chemicals (including DDT)--was further amended October 2, 1944.--U. S. WPB (397); Anon. (37, 46, 59); OPD Washington Bureau (333).

Except for small experimental quantities of DDT, none of this new insecticide material is available for the manufacture of products for civilian uses. All production is allocated by WPB and is going wholly for the manufacture of insecticides for the armed forces. A limited quantity may be made available later after production has been further increased, for certain agricultural insecticide purposes, but this is as yet not a certainty. To obtain small quantities even for research work, the WPB must be consulted as long as the product remains under present rigid government control.--Anon. (60).

Various writers from time to time have mentioned the fact that DDT is not available for civilian use.--Anon. (102), L. (293), and U. S. Department of Agriculture (390).

According to Appendices A, B, C to M-300, issued October 5, 1944, DDT comes under schedule 25, issued June 15, 1944. The customers' filing date (WPB-2945) is the 10th of the month, and the suppliers' filing date (WPB-2946) the 20th of the month; the small-order exemption is 1 pound for allocation period (month); no report on Form WPB-3442 is required and the initial allocation date was January 1, 1944.--United States War Production Board (398).

On October 1, 1944, it was reported that DDT was in Group I of materials, supplies of which are insufficient for war plus essential industrial demands within the limits imposed by existing administrative controlling orders.--U. S. War Production Board Conservation Division (400).

No announcement is near [October 23, 1944] of the release of supplies of DDT for civilian household or agricultural use.--Anon. (123).

Limited supplies of DDT will be available for agricultural experimentation.--OPD Washington Bureau (336).

Pending completion of agricultural research projects now under way [Nov. 1, 1944] Federal entomologists do not recommend DDT, the war-developed insect killer, for commercial agricultural use. Requests for DDT to be used for experimentation and development work should be submitted to WPB in triplicate on Form WPB-2945. A letter, in triplicate, should accompany each request containing the following information:

- (1) Name of the proposed supplier;
- (2) Total amount of material required;
- (3) Time when the material is needed;
- (4) Form in which the material is to be delivered (as 10 percent dust, 20 percent liquid concentrate, technically pure grade, etc.);
- (5) Pests against which the material will be tested; and
- (6) Nature of the experiments and where they will be conducted.

--U. S. War Production Board (399); Anon. (135).

With curtailed availability of pyrethrum, rotenone, and nicotine, California could use in 1945 about 40,000 pounds of DDT for control of grape leaf hopper, Parlatoria scale on olives, canker worms on deciduous trees, parasites on animals, scale insects on citrus trees, and for experimental work. At this time its use on leafy vegetables is not to be recommended.--Cox (216).

#### Canada

In September 1944 DDT had not yet been made in Canada. All imports of DDT have previously been required for the armed forces, but some civilian supplies are anticipated a little later in the year. Strict control is to be exercised over its distribution. All imports and inventories after July 1 must be reported to the administrator of Fertilizers and Pesticides of the Wartime Prices and Trade Board, and the product may not be sold, delivered, or processed without written permission from the administrator, or used for any purpose other than those authorized by the Pest Control Products Act.--Cook (214).

#### Great Britain

On November 3, 1944, it was stated that the chances were slender for release of DDT in England to growers (Anon. 131), but at the same time Abrahamson (171) and Anon. (115) reported that a small quantity was recently allocated to the Ministry of Health for use in air-raid shelters.

On October 27, 1944, it was reported that Salford, England, was the only authority outside London to which DDT had been issued for testing in the disinestation of homes. It was placed at the disposal of the Salford Health Department.--Anon. (125).

In supplement No. 3 to "The Raw Materials Guide" it was announced that all production of DDT is reserved for essential service requirements.--Anon. (130).

#### Australia

A plea for DDT supplies to control pests, specially the buffalo fly and cattle tick, was made in December 1944 by Wilson (412).

#### COST OF DDT

Effective September 4, 1944, the Office of Price Administration freed DDT from price control, because the constant change in specifications precluded any immediate and accurate determination of prices. --Anon. (97, 98, 137), [U. S.] Office of Price Administration (393).

The price of DDT in July 1944 was said to range between 85 cents and \$1.60 per pound. In October 1944 DDT dropped again in price. It has been reduced by at least one manufacturer from \$1.00 per pound to 75 cents.--Peaker (340).

### Cost of Manufacture

Basic economies of the Brothman continuous processes show up best in estimated manufacturing cost figures for the final product. Of the estimated net cost of considerably less than 30 cents per pound for DDT, raw materials alone account for almost 75 percent of the total cost, while steam, water, electrical energy, and labor amount to only about 8 percent, and overhead 17 percent. There seem to be sound reasons to hope that the selling price of undiluted DDT made by this process could be in the neighborhood of 50 cents per pound. After extension with inerts, a 10-percent DDT dust, for instance, could be marketed in household units for about 20-30 cents. --Callahan (193).

### Cost of Application

In 1944 the U. S. Public Health Service sprayed the inside of homes on 36 square miles of cotton country near Helena, Ark., with DDT to control mosquitoes. The job used an average of 0.82 gallon per house of 5 percent DDT solution. Per house it consumed 10 minutes, took 0.73 man-hour, and cost 74 cents for material and labor. --Anon. (164).

### PATENTS

When the Geigy patent application was filed in Washington on March 4, 1941, the military authorities, having come upon a potential major weapon, clamped down a firm secrecy order which prevented, until last summer [1943], the revelation of any phase of the amazing developments involved. --Geigy (258).

Application for a patent on the use of DDT as an insecticide was filed in Germany March 7, 1941, but no positive information is obtainable as to whether or not the German patent has ever been granted. --Anon. (92).

Geigy's British Patent 547,874 is abstracted in the Chemical Trade Journal and Chemical Engineer. --Anon. (83).

The information in United States Patent 2,349,814, granted Deonier and Jones (226) on May 30, 1944, is abstracted on page 62. of this digest.

United States Patent 2,358,942, granted Siegler (364) on September 26, 1944, is abstracted on page 51.

The Geigy Company, Inc., (259) owns United States Trade-Mark No. 409,820 on Gesapon.

### DDT IN AEROSOLS

The distribution of DDT as an aerosol from a liquefied-gas solution, first developed and described by Goodhue, has been mentioned by several writers.--15, 29, 56, 120, 127, 144, 150, 348.

### DDT IN PAINTS

Small-scale experiments to test the insecticidal value of paints containing DDT were carried out in the laboratory. Fly cages were lined with plywood painted with dry distemper, oil-bound water paint, white lead oil paint, and synthetic varnish enamel, each containing 5 percent of DDT. One hundred housefly pupae were placed in each cage with containers of sugar and water, and the cages were inspected from time to time. Good results were obtained with the dry distemper and with the oil-bound water paint, but not with oil paint and the enamel. The oil-bound water paint was found to have lost none of its effectiveness after 2 months, and was only very slightly less effective after 6 months. Tests were repeated on a larger scale with the oil-bound water paint, this time the DDT content being only 0.5 percent. Two waiting rooms were painted, one with paint containing DDT, the other with ordinary oil-bound water paint. Even at this low percentage the DDT paint killed 90 percent of the flies in 48 hours. The dining-room and kitchen of a factory canteen heavily infested with flies were then painted with paint containing 1 percent of DDT, and the bakery was left unpainted as a control. The number of flies decreased greatly during the first day after the painting, whereas the bakery was swarming with flies. The next morning hundreds of dead flies were lying on the floors, on window ledges, tables, etc. During the following days flies still entered the canteen, but most of them came into contact with the DDT paint and eventually died.-- Campbell and West (201, 203, 204); also West and Campbell (407).

It appears possible to formulate even oil paints and enamels in such a way as to allow the DDT to function as an insecticide. Moreover, there is evidence that DDT is effective in a coumarone-resin film and in a wax floor polish. In both instances DDT is enclosed in a continuous film, so that there would appear to be good prospects of successful formulation in the more decorative and durable paints.--West and Campbell (407).

One writer has suggested that DDT be incorporated in plastics or plastic films.--Anon. (88).

## POPULAR ARTICLES AND REVIEWS ON DDT

The story of the amazing toxicity of DDT to many insects has caught the popular fancy, and innumerable articles have been published in newspapers, popular magazines, and trade journals describing its value for the control of lice, flies, mosquitoes, cockroaches, codling moths, Japanese beetles, and other injurious insects. These accounts are based chiefly on the reports of tests by personnel of the Bureau of Entomology and Plant Quarantine which were published in the February 1944 number of the *Journal of Economic Entomology*; on the talks by Ahnfeldt (174) and Froelicher (247) and the press releases of the Geigy Company (254, 255, 256, 258).

Excellent reviews of the available information on DDT have been published in England by Campbell and West (196, 197, 198, 200, 202); Chambers, Hey, and Smitt (207); Martin and Wain (321); and West and Campbell (406).

That DDT is not effective for all purposes and needs further testing was pointed out by the United States Department of Agriculture (390) in a press release, June 28, 1944, which outlined the nature of the additional tests that should be made. Attention has been called to the contradictory nature of many of the tests of DDT. --Anon. (100, 126).

## MISCELLANEOUS

Basle University, Switzerland, has conferred an honorary M. D. upon Paul Lauger, technical director of J. R. Geigy, A. G., for his work with Gesarol, Neocid, and other DDT compositions. --Anon. (156).

An expert in such things has figured that over the past 3 months, [prior to July 1944] DDT has received about two million dollars worth of free newspaper advertising at space rates. --Anon. (61).

There are some new synthetics that will also be of interest; for instance, British patents 547871 and 547874, issued during 1943 to Geigy and Company, contain reference to a new synthetic organic material [DDT]. This insecticide is now being produced in the United States. It has been tested by a number of government agencies and particularly by the Bureau of Entomology and Plant Quarantine. --Groggins (266).

"The discovery and the field application of DDT to the control of insect-borne diseases, will, in my opinion, prove to be the outstanding medical advance made during this war. It will exceed even penicillin in its ultimate usefulness in the preservation of health and the saving of human lives."--Simmons (366, pp. 408-409).

A high tribute to the value of DDT was paid by Winston Churchill in his review of the war situation in the House of Commons late in September 1944.--Anon. (114).

DDT is not in itself a complete insecticide, but is a toxicant which to be effective requires very careful compounding with other compatible substances that act as diluents or carriers.--Anon. (167).

The Bureau of Entomology and Plant Quarantine developed the insecticidal uses of DDT in this country.--Fielaner (240).

#### INSECTICIDAL VALUE

This second digest of the literature on DDT abstracts 418 articles which describe tests against 151 identified species of insects and other arthropods belonging to 17 orders, 63 families and 124 genera.

#### CRUSTACEA

##### Isopoda

##### Wood lice

Both Gesarol and a dust containing 0.8 percent of DDT were effective as contact poisons.--Martin et al. (319).

#### THYSANURA

##### Lepismatidae

##### Lepisma saccharina L., the silverfish

DDT goes to work with a vengeance against silverfish.--Anon. (55).

Practical field tests are being made with DDT to determine its value for the control of silverfish. This is a cooperative project between the National Pest Control Association Research Projects Committee and the Bureau of Entomology and Plant Quarantine.--Anon. (63).

#### COLLEMBOLA

Gesarol dust is used in gardens to control ground fleas.--Messerli (323).

ORTHOPTERA

Acrididae

Melanoplus spp., grasshoppers

Preliminary experiments indicated that DDT is very promising.--U. S. Bur. Ent. and Plant Quar. (388, p. 9).

Blattidae

Blattella germanica (L.), the German cockroach

Until the discovery of DDT, which may be potent for roach control, sodium fluoride was probably the most effective substance known for speedy and lasting control of German roaches. Being cheaper than DDT, it will not be easily ousted for this purpose.--Campbell (195).

Periplaneta americana (L.), the American cockroach

Radioactive bromine was used to prepare dibromodiphenyltrichloroethane, m.p. 139.0-139.5°. A saturated solution of this compound in Gellosolve was applied to the posterior thoracic tergites of adult roaches over a period of 8 hours, and within 24 hours all the insects were very torpid or dead. Radioautographs of dissected material showed the presence of the bromine homologue of DDT in the nerve cord and brain as well as in other parts of the treated insects.--Hansen et al. (273).

Nontechnical references on cockroaches

DDT has been found effective against roaches, and field tests are being conducted to determine the best type of preparation to adopt.--Anon. (18).

DDT is effective against roaches.--Anon. (27, 28, 33, 55, 75, 78); Brazelton (188); Cameron (194).

A dairy barn in Florida was sprayed with DDT and 10 days afterwards cockroaches were still dying as a result.--Watson (405).

The application of DDT from a pressure paint sprayer for killing cockroaches is shown in a photograph.--Anon. (51).

According to Sameth, chairman of the Technical Committee of National Pest Control Association, "The roach control picture is not so clear; 23 tests initiated, 19 completed. Results from six were superior to prevailing methods; 12 were equal, 1 was inferior. Reinfestation will occur but we'll get the answer to that next."--Anon. (150). For roach control DDT is equal to sodium fluoride. Reinfestation is possible where DDT is used.--Anon. (169).

DERMAPTERA

Forficulidae

Forficula auricularia L., the European earwig

Good results have been obtained with DeDeTane and with DDT in emulsion and dust form, but a relatively high concentration of DDT in the preparation is necessary.--Chambers, Hey, and Smitt (207, 208).

Forficula spp.

Both Gesarol and DDT at a strength of 0.8 percent deposited from an acetone solution on a mixture of 95 percent gypsum and 5 percent amorphous silica were effective as contact insecticides.--Martin et al. (319).

ISOPTERA

Rhinotermitidae

Cryptotermes brevis (Wlk.), the West Indian dry-wood termite

Samples of wood dipped in a petroleum ether solution of DDT were very repellent and toxic to the termites, even at the greatest dilutions. A few weeks later, however, fresh termites ate deeply of the sample treated with 1 percent of DDT, without any apparent deleterious effects. --Wolcott (414).

Nontechnical references

DDT is deadly to termites.-- 22, 30, 32, 33, 55.

MALLOPHAGA

Menoponidae

Eomenacanthus stramineus (Nitz.), the chicken body louse

Menopon gallinae L., the common chicken louse

Dusts containing 4 percent of DDT, 0.5 percent of nicotine, and 33 percent of sodium fluoride in pyrophyllite were efficacious in the control of E. stramineus. The DDT freed all birds of lice within 28 hours; the sodium fluoride within 52 hours. No apparent harmful effects, either upon the operator or the 24 two-year-old hens, resulted in the use of these materials.--Telford (381, 382).

THYSANOPTERA

Thripidae

Frankliniella fusca (Hinds), the tobacco thrips

Frankliniella tritici (Fitch), the flower thrips

Hercothrips fasciatus (Perg.), the bean thrips

In preliminary tests in Louisiana, Texas, and Arizona encouraging results were obtained with DDT against thrips on cotton.--U. S. Bur. Ent. and Plant Quar. (388, p. 19).

Scirtothrips citri (Moult.), the citrus thrips

From limited field experiments the following statements appear to be warranted: Of new materials tested during the past season DDT was the most effective; control was better with DDT sprays than with DDT dusts; DDT sprays were about as effective as the regular nicotine program now being used; DDT offers promise as a combination treatment for citricola scale and citrus thrips on oranges in central California.-- Calif. Fruit Growers Exchange (192).

DDT has been found to be very toxic to the citrus thrips, but further work is needed before it can be recommended for the control of this insect.--McGregor (316).

Taeniothrips simplex (Morison), the gladiolus thrips

Encouraging but not outstanding results were achieved with DDT.-- U. S. Bur. Ent. and Plant Quar. (388, p. 13).

DDT sprays gave about the same control as the tartar emetic-sugar spray.--Blauvelt (186).

Thrips nigropilosus Uzel, the chrysanthemum thrips

Greenhouse tests on heavily infested chrysanthemums showed that these thrips were extremely susceptible to DDT, rates as low as 1 ounce per 100 imperial gallons giving almost complete kill of the larvae and a high kill of adults. The control by sprays of DDT-talc-Orvus appeared to be just as high as by formulas containing Velsicol or acetone. Two applications of a DDT emulsion (DDT 10 g., Triton S-100 10 ml., Velsicol AR 60 to make 100 ml.) diluted to give 4 ounces of DDT per 100 gallons gave complete control. Eggs were apparently not killed, but the residue killed the newly hatched larvae.--Ross (354).

Experiments by G. G. Duston in Canada indicate that DDT in certain spray formulas is very effective against this thrips.-- Blauvelt (186).

Thrips tabaci Lind., the onion thrips

Two applications of a spray containing 0.13 percent of DDT, used at the rate of 190 gallons per acre of onions, gave a better control of the nymphs than a number of recommended treatments.--Lange (294).

Encouraging but not outstanding results were achieved with DDT. --U. S. Bur. Ent. and Plant Quar. (388, p. 13).

Thrips on orchids

A single spraying of DDT destroyed orchid thrips and prevented reinestation for 4 months.--W. B. (180).

Nontechnical references

DDT was found effective against thrips.--24, 32, 212, 255.

HOMOPTERA

Aleyrodidae

Aleurothrixus howardi (Quaint.), the woolly whitefly

Plants dusted with Gesarol or sprayed with a 1-percent suspension of it are protected for a long time. A spray containing 2 percent of a white, medium-light emulsible oil and 30 to 40 grams of Gesarol-Spritzmittel per 100 liters of water can be used also.--Hayward (274).

Trialeurodes spp., whiteflies

In Brazil whiteflies in greenhouses were easily controlled with monthly sprayings of a 1-percent suspension of Gesarol A (5 percent DDT). The spray did not injure the most tender plants.--Lepage and Giannotti (297).

Aphiidae

Anuraphis roseus Baker, the rosy apple aphid

Apple trees sprayed in 1943 for codling moth were examined for aphids in April 1944. Trees that had been sprayed with DDT were infested with fewer aphids than were trees that had been sprayed with lead arsenate or nicotine bentonite. By applying a 10-percent DDT dust to infested branches of apple trees a knock-down of most aphids present has been obtained within 2 hours.--Steiner (375).

Aphis gossypii Glov., the cotton aphid

None of the synthetic materials tested, including DDT, showed much promise. In preliminary tests in Louisiana, Texas, and Arizona, DDT was less effective than nicotine.--U. S. Bur. Ent. and Plant Quar. (388, pp. 16, 17, 19); Anon. (113).

Aphis pomi Deg., the apple aphid

Same as for Anuraphis roseus.--Steiner (375).

Eriosoma lanigerum (Hausm.), the woolly apple aphid

In the Northwest this aphid has become extremely abundant in DDT-sprayed apple trees, raising the question of a possible recurrence of perennial canker, to which this aphid is a contributing factor. The increase in aphids is assumed to be due to the effect of DDT on parasites or predators.--Porter (342).

Macrosiphum pisi (Klth.), the pea aphid

In preliminary field tests DDT was very effective.--U. S. Bur. Ent. and Plant Quar. (388, p. 13).

Excellent results were obtained with Gesarol A3 Dust (3 percent DDT).--Ceigy Co. (255).

Rhopalosiphum prunifoliae (Fitch), the apple grain aphid

Same as for Anuraphis roseus.--Steiner (375).

Rhopalosiphum pseudobrassicae (Davis), the turnip aphid

Unsatisfactory or indifferent results were obtained with DDT.--U. S. Bur. Ent. and Plant Quar. (388, p. 13).

Rhopalosiphum rufomaculatum Wilson, the green chrysanthemum aphid

Greenhouse tests against this aphid, which is very resistant to nicotine, afforded further proof of the superiority of the contact action of DDT in Velsicol or acetone over the so-called dry spray formulas. The DDT-talc-Orvus formula, diluted to 4 ounces of DDT per 100 imperial gallons, reduced an aphid population of 1500 per 10 tips to 567, while the DDT-Velsicol-Triton X-100 at the same rate reduced it to 55.--Pess (354, p. 7).

Nontechnical references

DDT has been found effective against some aphids.--5, 9, 11, 13, 23, 24, 28, 32, 33, 75, 78, 212, 227, 255.

Cicadellidae

Ophiola striatula (Fall.), blunt-nosed cranberry leafhopper

Four tests were made with DDT dust against the cranberry leafhopper in New Jersey during the summer of 1944. According to preliminary results, it appears desirable to use at least 50 pounds of 3 percent DDT dust per acre of cranberries. Pyrethrum was as effective as DDT.--Doehlert (227).

Empoasca fabae (Harr.), the potato leafhopper

Although the data on the control of this species were not so striking at 1 to 2.5 percent concentrations as for the potato flea beetle, at a 5 percent concentration DDT was very effective against the leafhoppers for nearly 2 weeks between the dusting operations. --Granovsky (263).

Pyrax ABB dusts containing 1, 2.5, and 5 percent of DDT applied at 25 and 30 pounds per acre were effective in field experiments at three locations in Minnesota. The 1-percent dust reduced the population 72 percent at the end of 2 days, but at the end of 6 days the population had built up to within 2 percent of its original level. --Granovsky (264).

In an experiment with 44 materials sprayed on late-planted Dakota Red potatoes, DDT (0.75 pound per 100 gallons of water) was used alone and in combination with two fungicides (copper oxychloride and zinc dimethyl dithiocarbamate) in a five-application spray schedule. The leafhopper counts averaged 7.6 per 20-foot row for those treated with fungicides and those untreated, and averaged 1 for DDT alone or combined with the fungicides. --Heuberger and Wolfenbarger (277); abstracted by Anon. (160).

In preliminary field tests DDT was very effective. --U. S. Bur. Ent. and Plant Quar. (388, p. 13).

A 3 percent dust will control the potato leafhopper. --Geigy Co. (255).

Empoasca maligna (Walsh), the apple leafhopper

A 3 percent Gesarol dust gave excellent control. --Geigy Co. (255).

Eutettix tenellus (Bak.), the beet leafhopper

Encouraging but not outstanding results were obtained with DDT. --U. S. Bur. Ent. and Plant Quar. (388, p. 13).

Macrosteles divisus (Uhl.), the six-spotted leafhopper

This leafhopper behaves in regard to DDT much in the same way as Empoasca fabae. --Cranovsky (264).

Unidentified Cicadellidae

DDT both as a spray and as a dust will knock out leafhoppers. --Anon. (28, 32).

Coccidae

Aonidiella aurantii (Mask.), the California red scale

DDT was applied to citrus trees in light-medium oil or in kerosene as oil-water emulsion. Some effect of it persisted up to the 26th week after spraying. Dusts containing 4 percent of DDT applied to fruit did not prevent all red scale crawlers from settling or developing, nor did 2 pounds of DDT in 100 gallons of water applied as a spray. --Lindgren and LaDue (305, 306).

In laboratory tests oil-water emulsion (0.75 percent of oil) alone killed 26 percent of the female adult scales, but the kill was increased to 56 percent when DDT was added at the rate of 6 grams per 100 ml. of oil. With the oil alone 1050 young settled and developed per grapefruit, while with 4 or 6 grams of DDT added per 100 ml. of oil practically no young developed on the fruit. Other tests showed that the kill of all stages of the red scale was increased by the addition of DDT to either kerosene or mineral seal oil. The kill of the younger stages was strikingly increased, but that of the late gray adult and the mature adult female less so. One percent of mineral-seal oil plus 1.7 gram of cube plus 4 grams of DDT per 100 ml. of oil killed 99 percent of adult female scales, and the residue killed 100 percent of the young. When a similar mixture containing 3 percent of kerosene was tested, 96 percent of the females and 100 percent of the young died. Other similar mixtures containing 8 or 6 grams of DDT were sprayed on lemon trees. Forty days after spraying some settling but no development of young scales was obtained on fruit picked from these trees treated with DDT, either in light-medium oil or kerosene. --Lindgren and coworkers (307); reviewed by Burnet (191).

The kill of mature insects with DDT has not been significant. Its greatest effectiveness is against crawlers and prevention of their settling. When used as a dust, the results with upwards to 5 percent strength DDT have been of little value against red scale in any stage. DDT is most effective as a spray and has been used in kerosene and spray oil. At strengths up to 5 percent in kerosene solutions the results in the field are not equivalent to an ordinary oil spray. The addition of DDT to oil spray increases the duration of the crawler kill somewhat, but on the basis of preliminary results even amounts up to 4 percent strength in light medium oil have not increased the kill in significant degree after a few months over that of oil alone. The failure of DDT in the field to meet expectations is possibly due to its decomposition under summer field conditions. Attempts will be made to determine why decomposition occurs and whether it can be eliminated as a factor in reducing the effectiveness of DDT. --Calif. Fruit Growers Exchange (192).

At the Citrus Experiment Station, Riverside, Calif., DDT sprayed in a 1.75-percent oil emulsion (6 grams per 100 ml. of oil) gave an exceptionally effective control of the settling and development of the larvae for more than 50 days. It appeared, moreover, to be efficient on the larvae that tried to settle and develop on the bark. The

use of oil alone caused a large destruction of the immature stages and adult females, although the combination of oil and DDT was the most promising. DDT in 3-percent kerosene emulsion (8 grams per 100 ml. of oil) was very effective in the control of the development of the crawling larvae, but it only partially controlled the settling of them.-- Rosenberg (353).

Chrysomphalus aonidum (L.), the Florida red scale

DDT is being tried in Florida on grapefruit infested with both the Florida red scale and the purple scale, with results similar to those obtained in California against the California red scale.-- Watson (405).

Lepidosaphes beckii (Newm.), the purple scale

The effect of DDT on settling and development of the young scales was practically the same as for Aonidiella aurantii. Under laboratory conditions 4.5 percent of DDT in kerosene or mineral-seal oil inhibited all the young from developing for 45 days. DDT in oil was toxic, but when cube root was added to this spray mixture the kill was increased. --Lindgren and LaDue (305, 306).

The effect against purple scale in the laboratory appears to be comparable to that against red scale. DDT dissolved in oil will penetrate somewhat into the outer peel (flavedo), where it is not removed by washing.--Calif. Fruit Growers Exchange (192).

Same as for Chrysomphalus aonidum.--Watson (405).

Pseudococcus citri (Risso), the citrus mealybug

Various formulas diluted to give 8 ounces of DDT per 100 imperial gallons were applied to coleus heavily infested with mealybugs. Observations showed practically no kill of adults or larger larvae, but the following kills of the young crawlers: DDT 10 grams, Triton X-100 10 ml., and Velsicol AR-60 to make 100 ml., 54.5 percent; and DDT 10 percent, talc 87 percent, and Orvus 3 percent, 1.1 percent.--Ross (354, p. 8).

Pseudococcus comstocki (Kuv.), the Comstock mealybug

DDT (1.5 lb. per 100 gal.) in two sprays (July 5 and 14) and four sprays (July 5, 14, and 25, and August 5) applied against the young of the second generation resulted in 7.9 and 3.5 percent of infested apples, respectively, at harvesttime in September, compared with 69.4 percent on the check trees. In laboratory tests the DDT affected the young mealybugs but not the mature females. After 24 to 48 hours the paralyzed young fell from the fruit. DDT applied in oil also seemed to kill the young mealybugs. The toxicity of the spray deposit was considerably higher immediately after the treatment than 12 to 13 days later.--Hough (284).

In laboratory tests badly infested seed potatoes in Brazil were dusted with Gesarol P (containing 3 percent of DDT). After 40 days mealybugs on these tubers were still absent but the untreated potatoes remained badly infested.--Lapage and Giannotti (297).

Pseudococcus maritimus (Ehrh.), the grape mealybug

Same as for Pseudococcus comstocki.--Lapage and Giannotti (297).

Unidentified mealybugs, Nontechnical references

DDT in certain spray formulas is not satisfactory against mealybugs.--(186).

DDT spray was less effective against mealybugs than against scale insects. DDT dust gave fair control.--W. B. (180).

Saissetia oleae (Bern.), the black scale

DDT had the same effect on settling and development of young scales as described for Aonidiella aurantii. No crawlers settled and developed on potato sprouts sprayed with DDT dissolved in benzene, kerosene, or mineral-seal oil applied as oil-water emulsion. On the checks several hundred young settled and developed per sprout.--Lindgren and LaDue (305, 306).

Unidentified scales

Two benches of orchid plants, each 150 feet long, were allowed to become well covered with orchid scale. One bench was then dusted with DDT, while the other bench was treated according to the current popular method of scrubbing plants to control the scale. On the treated bench there was no increase in the orchid scale except on new growth. On the scrubbed plants there was a continued increase in the amount of the scale on both the old and the new growth. A small number of palms were treated with DDT and a few were left untreated. Again, on the old growth of the treated plants no new scales developed, but on the new growth as well as on the untreated plants the amount of scale increased. In the case of Boston Fern scale, the treated plants showed no new scales, although the old scales did not die, nor did they reproduce, while there was an increase in the amount of scale on all parts of the untreated plants.--W. B. (180).

Psyllidae

Paratrioza cockerelli (Sulc.), the potato psyllid

In Colorado DDT appeared to be a much more effective killer of psyllids than lime-sulfur spray. Every psyllid on infested laboratory plants was killed within 3 weeks with DDT dust.--Geiger (249); also Anon. (91).

HEMIPTERA

Cimicidae

Cimex lectularius L., the bedbug

Under an extensive research program developed by the Bureau of Entomology and Plant Quarantine and the War Production Board Office of Civilian Requirements, pest-control operators selected by the National Pest Control Association are cooperating with these agencies in conducting field experiments. It is planned to test DDT under various conditions. In 29 completed tests out of 35, it was shown that in comparison with other control methods DDT was superior in 26 cases, or in 89 percent.--Stenerson (378); abstracted by Anon. (63, 151).

Sameth, chairman of the National Pest Control Association committee, stated: "Indications are that DDT will be among the chemicals used in bed bug control. Tested against prevailing methods, it has been found superior to what the average PCO has used."--Anon. (150, 169).

Nontechnical references

DDT is very toxic to bedbugs.--18, 26, 27, 28, 32, 33, 40, 51, 55, 68, 75, 169, 186, 188, 194, 201.

Lygaeidae

Blissus leucopterus (Say), the chinch bug

Preliminary experiments indicated that DDT is a very promising insecticide against this pest on corn.--U. S. Bur. Ent. and Plant Quar. (388, p. 9).

Miridae

Adelphocoris lineolatus (Goeze), the alfalfa plant bug

Adelphocoris rapidus (Say), the rapid plant bug

DDT was very effective against mirids on potatoes. The mortality of the mirids increased while that of flea beetles decreased in the period of 6 days after dusting.--Granovsky (263).

These bugs respond to DDT in the same pattern as does the tarnished plant bug.--Granovsky (264).

Halticus bracteatus (Say), the garden fleahopper

A plot in Florida dusted with 3 percent Gesarol dust in the fall of 1943 was "devoid of insect life" and could be picked out from a distance by the taller and greener growth.--Geigy Co. (255).

Lygus oblineatus (Say), the tarnished plant bug

Pyrax ABB dusts containing 1, 2.5, and 5 percent of DDT applied at rates of 25 and 50 pounds per acre were effective in field experiments at three locations in Minnesota. The 1-percent dust reduced the population 45 percent in 2 days and 83 percent in 6 days.--Granovsky (264).

DDT was very effective in laboratory tests and may be useful for controlling this pest on mums, dahlias, and other flowers often injured by it.--Blauvelt (186).

Lygus spp., plant bugs

In preliminary field tests DDT was very effective against Lygus plant bugs, and in Louisiana, Texas, and Arizona encouraging results were obtained against plant bugs on cotton.--U. S. Bur. Ent. and Plant Quar. (388, p. 13); also Geigy Co. (255).

Pentatomidae

Unidentified stinkbugs

Encouraging but not outstanding results were achieved with DDT against stinkbugs of various species on truck crops. In preliminary tests in Louisiana, Texas, and Arizona, encouraging results were obtained with DDT against stinkbugs on cotton.--U. S. Bur. Ent. and Plant Quar. (388).

Bagrada hilaris (Burm.), the Bagrada bug

In laboratory tests a weak solution of DDT was tested as a spray against this species, which is a common pest of cruciferous plants in Pretoria. They became paralyzed, did not feed, and died within 3 days.--Hepburn (275).

Triatomidae

Mestor megistus (Burm.)

Rhodnius prolixus Stål

Triatoma infestans (Klug)

Triatoma sordida (Stål)

Neocid, which contains 5 percent of DDT absorbed in talcum powder, was applied in Brazil to these bugs, which transmit the American trypanosomiasis (chagas disease). The bugs were confined in petri dishes containing the insecticide. The effect of DDT was generally slow, but it was more rapid against the adults than the nymphs, the last nymphal instar being the most resistant. The insects showed the first symptoms of paralysis within 18 to 24 hours. Pure DDT in crystal form did not have a more rapid effect than Neocid. DDT did not prevent embryological development of the insects. R. prolixus,

2 hours after sucking blood from a pigeon fed 0.45 to 0.50 gram of DDT, exhibited the usual symptoms of DDT poisoning.--Lent and Oliveira (299).

#### ANOPLURA

##### Haematopinidae

Haematopinus eurysternus Nitz., the short-nosed cattle louse

DDT was found to be remarkably effective against this and other less resistant species of cattle lice. As little as 0.06 percent of DDT in a water suspension gave complete mortality of the motile stages of all species of cattle lice.--U. S. Bur. Ent. and Plant Quar. (388, p. 23).

Linognathus stenopsis (Burm.), a blue louse on goats

Emulsions containing 0.1 percent of DDT killed the motile stages of all species of lice on Angora goats, and the material from a single dipping remained in the hair long enough to kill the young lice that hatched from the eggs. [Five species of lice infest goats in the United States.]--U. S. Bur. Ent. and Plant Quar. (388, p. 23).

#### Pediculidae

Pediculus humanus corporis Deg., the body louse

Pediculus humanus humanus L., the head louse

Measures for louse control developed by the Bureau of Entomology and Plant Quarantine, and recommended to the Army and Navy, were used in stamping out a typhus epidemic in Naples, Italy, during the winter of 1943-1944. As a result of this experience a high official in the War Department stated that typhus has become one of the easiest diseases of man to control.--U. S. Bur. Ent. and Plant Quar. (388, pp. 1, 21).

A powder known as NYL killed lice for 1 to 2 weeks, and in most instances a single treatment was sufficient. Ten percent of DDT in pyrophyllite gave protection for 2 to 3 weeks and sometimes longer. This material remained in the clothing long enough to kill the young as they hatched from the eggs; it was therefore not necessary to add an ovicide as was done in the NYL treatment. These powders have been adopted by the armed forces and have been the means of controlling typhus epidemics in the present war.--Dove (228).

DDT proved to be not only a suitable substitute for pyrethrum but one whose effectiveness against lice was retained for 30 days as compared with the 7 days for the NYL pyrethrum powder. After a great many toxicological studies, the safety of DDT under the conditions of its Army use was established, and on May 26, 1943, a mixture of 10 percent DDT in pyrophyllite was adopted for use. In one prisoner of war camp, 252 men were selected as a group. Lice were found

on 77 percent of these men. The entire group of men were then dusted with DDT louse powder. Re-examination of 151 of these men 16 days later failed to reveal the presence of a single louse. During December 1943 and January 1944 a relatively large outbreak of louse-borne typhus occurred in Naples, and spread rapidly, constituting a serious potential threat to our troops. The U. S. A. Typhus Commission, AMG officials, and a typhus control team of the Rockefeller Foundation Health Commission, working in close cooperation with the Army Medical Corps, took prompt and vigorous measures to suppress it. DDT was applied at mass dusting stations which were set up all over Naples. Over a million and a half individuals were deloused with DDT powder in less than 1 1/2 months. Some stations were able to dust as many as 5,000 people a day, and during the early control period over 50,000 persons were deloused daily in Naples. The epidemic was stopped, and to date no case of typhus has been reported in an American soldier in Italy. The impregnation of underwear with a DDT emulsion has proved in tests to be a practical procedure. An emulsion that retains its effectiveness against lice after the clothing has been laundered eight times extended over 2 months. "I firmly believe that the discovery of DDT now being applied to the use of the Armed Forces offers the hope of a new era of insect control and will rank with the really great discoveries in medicine of the past century. DDT will be to preventive medicine what Lister's discovery of antiseptics was to surgery, and should close the door forever on those diseases which are companions of deathdealing insects."--Ahnfeldt (174).

Experiments on delousing with insecticide powders were conducted from June 1943 to January 1944 in Algeria, North Africa. In all, 14,000 people were treated, including those in a penitentiary group and others in rural communities. In the penitentiary group daily counts showed progressive disappearance of the lice after a single dusting with DDT powder and after two dustings with MYL powder within 18 hours, and the delousing was practically complete. In the control of typhus the practical instructions include the delousing of all the inhabitants by using dusting insecticides.--Sargent and Beguet (363).

DDT in the form of 10 percent powder in pyrophyllite kills lice in 2 to 6 hours. While it does not kill louse eggs, it persists in clothing and kills the young insects as soon as they emerge from the hatched eggs. It persists as an insecticide for at least a month and can be dusted into clothing by hand or power dusters. Persons can be deloused with their clothes on, making unnecessary the cumbersome establishments for undressing and dressing, bathing, and steam sterilization of clothing familiar to veterans of the last war. Thousands can be deloused by a few persons and in the same time and with far less effort than a few hundreds could have been before the discovery of DDT. A report of a talk by Brig. Gen. Stanhope Bayne-Jones, deputy chief of the preventive medicine service in the Office of the Surgeon General, U. S. Army, and director of the United States of America Typhus Commission, at the meeting of the National Academy of Sciences. --Anon. (145).

Nontechnical references

Brief accounts of the composition of the Army's DDT louse powder and of its successful use in North Africa and Naples to combat typhus are given by numerous writers—for example: 1, 2, 4, 5, 6, 7, 9, 11, 12, 13, 15, 17, 18, 25, 29, 30, 31, 32, 33, 34, 43, 50, 56, 67, 75, 76, 95, 116, 142, 161, 182, 183, 194, 337, 345, 346.

DDT is toxic to body lice. 8, 10, 22, 24, 26, 27, 28, 51, 53, 55, 57, 68, 74, 78, 79, 80, 84, 88, 102, 113, 141, 175, 186, 188, 249, 395.

"It has been reported that the German authorities made use of the synthetic in their African campaign but this report is unconfirmed."—Anon. (67).

COLEOPTERA

Bruchidae

Bruchus brachialis Fahraeus, the vetch bruchid

Bruchus pisorum (L.), the pea weevil

Encouraging results were obtained with DDT against these bruchids. --U. S. Bur. Ent. and Plant Quar. (388, pp. 9, 13).

Byturidae

Byturus tomentosus (Deg.), the raspberry beetle

In laboratory tests Gesarol spray killed 37 out of 40 beetles in 31 hours and visibly affected the remaining 3. Gesarol dust killed all 40 insects in the same time.—Sotz (262).

Gesarol powder applied at the rate of 30 kg. per hectare killed 67 percent in 1 day and 53 percent in 2 days.—Denmark Statens Forsog. (225).

Nontechnical references

In 1939 Gesarol was found effective against raspberry fruit worm.—Campbell and West (202); also Anon. (24).

Chrysomelidae

Cerotoma trifurcata (Forst.), the bean leaf beetle

Encouraging but not outstanding results were obtained against these beetles.—U. S. Bur. Ent. and Plant Quar. (388, p. 13).

Crioceris asparagi (L.), the asparagus beetle

Crioceris duodecimpunctata (L.), the spotted asparagus beetle

In greenhouse tests a marked difference in resistance to DDT was shown by these two species. C. asparagi was very susceptible; 100 percent mortality resulted within 3 days, when the beetles were confined in glass jars with asparagus tips sprayed with DDT, 1 ounce per 100 imperial gallons of water. C. duodecimpunctata was very resistant; 13 percent of the beetles survived for 7 days after the plants had been sprayed with 16 ounces of DDT per 100 gallons. When 32 ounces of DDT per 100 gallons were used, 100 percent mortality of this species resulted after 5 days. The same relative difference between the two species was noted for a contact spray of DDT in Velsicol. The asparagus beetles were readily killed by 8 ounces of DDT per 100 gallons, while the majority of the spotted asparagus beetles survived spraying with 16 ounces of DDT per 100 gallons.--Ross (354, p. 8).

Diabrotica 11-punctata Mann., the 11-spotted cucumber beetle

A dust containing 3 percent of DDT, applied at the rate of 20 pounds per acre, was recommended in Oregon. It was the most effective insecticide tested. The date and number of dustings, and interval between dustings are the same as given for Epitrix tuberis.--Gray and Schuh (265).

Diabrotica sp.

Gesarol dusts and sprays are effective.--Geigy Co. (255).

Epitrix cucumeris (Harr.), the potato flea beetle

Preliminary field tests with dusts containing 1, 2.5, or 5 percent DDT definitely indicated that DDT is safe to use on potatoes. It was efficient in the control of flea beetles in as low a concentration as 1 percent in Pyrax ABB. DDT was superior to any insecticide heretofore used, and it had a residual value.--Granovsky (263).

Pyrax ABB dusts containing 1, 2.5, and 5 percent of DDT applied at the rate of 25 and 30 pounds per acre were highly effective in field experiments at three locations in Minnesota. The 1-percent dust reduced the population more than 90 percent 2 days after dusting, and the reduction was maintained for at least a week on a high level. --Granovsky (264).

DDT was used successfully in combating this pest on potatoes at the Washington County (Ohio) Truck Farm.--Walp (402).

In preliminary field tests DDT was very effective against flea beetles on potatoes.--U. S. Bur. Ent. and Plant Quar. (388, p. 13).

DDT dusts are already known to be effective, though actual concentrations have yet to be determined, as has the possibility of using DDT preparations with spraying machine.--Chambers, Key, and Smitt (208).

Epitrix tuberis Gentner, the tuber flea beetle

A dust containing 3 percent of DDT, applied at the rate of 20 pounds per acre, was recommended for control of this insect on potatoes in Oregon. When tested in field plots and under commercial field conditions during the 1944 growing season, it was found to be at least as effective as the currently recommended dust containing 20 percent of calcium arsenate plus 0.5 percent of rotenone. It is suggested that dusting be begun May 15 and be continued at 5 to 7 day intervals until June 25. Apply the first dust to the entire field when one-half to two-thirds of the plants are up, and apply the succeeding dusts to parts of the field showing the presence of beetles at 5- to 7-day intervals until June 25, and every 10 to 14 days until July 15; again reduce the interval to 5 to 7 days until August 20. Continue dusting until September 20. Directions are also given for dusting late potatoes. No trace of DDT was found on potato tubers from the DDT plots.--Gray and Schuh (265).

Results of field experiments in western Nebraska indicated that DDT, either as a 3 percent dust or as a spray (4 lb. of 10 percent DDT to 100 gal.), gave very good control of flea beetles on potatoes.--Hill and Tato (280).

Nontechnical references

Gesarol was found effective against flea beetles.--(24, 202).

Leptinotarsa decemlineata (Say), the Colorado potato beetle

In preliminary field tests DDT was very effective.--U. S. Bur. Ent. and Plant Quar. (388, p. 13).

In Florida DDT promptly killed this beetle, the adults of which are considered rather difficult to poison.--Watson (405).

A low concentration of DDT was toxic to the beetles, especially the larvae.--Granovsky (263).

DDT dusts effectively control this insect, especially in larval stages.--Granovsky (264).

Gesarol dust containing as little as 1 percent of DDT repeatedly has given good protection against this beetle.--Geigy Co. (255).

Phyllotreta spp.

Gesarol powder at the rate of 20 kg. per hectare killed 96.9 percent in 1 day, and proved slightly better than derris.--Denmark Statens Forsog. (225).

### Nontechnical references

DDT is effective against potato beetles.--15, 24, 30, 32, 33, 34, 75, 78, 113, 144, 188, 202.

### Coccinellidae

#### Epilachna varivestis Muls., the Mexican bean beetle

Unsatisfactory or indifferent results were obtained with DDT.--U. S. Bur. Ent. and Plant Quar. (388, p. 13).

### Nontechnical references

DDT is ineffective against Mexican bean beetles.--15, 23, 28, 32, 33, 55, 113.

#### Cryptolaemus sp.

DDT kills beneficial insects such as Cryptolaemus, which holds the mealybug in check. If the Cryptolaemus are destroyed infestation of mealybug may increase.--Anon. (86, 94).

### Unidentified coccinellids

DDT is destructive to lady beetles.--Calif. Fruit Growers Exchange (192).

### Curculionidae

#### Acanthoscelides obtectus (Say), the bean weevil

In Brazil a mortality of 100 percent was obtained in 48 hours by using 0.5 gram of Gesarol (containing 3 percent of DDT) per kilogram of beans. Seed beans may be preserved and protected by using the same dosage as recommended against Sitophilus oryzae in mullet seeds.--Lepage and Giannotti (297).

#### Anthonomus eugenii Cano, the pepper weevil

In laboratory tests in 1943 DDT was more toxic than any material previously tested against the pepper weevil in California. Pyrophyllite dusts containing 3, 5, or 10 percent of DDT gave 100 percent mortality within 24 hours after application. Plants treated with DDT appeared to be completely protected from weevil feeding. The weevils were not able to stay on the leaves or buds for more than a few seconds at a time, and the dust adhered well to the foliage. In these tests the weevils were placed on twigs of pepper after dusting.--Campbell (205).

#### Anthonomus grandis Boh., the boll weevil

Barium fluosilicate, cryolite, DDT, and other materials tested were all inferior to calcium arsenate. In preliminary experiments in Louisiana, Texas, and Arizona, DDT was less effective than calcium arsenate.--U. S. Bur. Ent. and Plant Quar. (388, pp. 16, 18); also Anon. (113).

Nontechnical references

DDT is ineffective against cotton boll weevils.--15, 32, 33, 55. The erroneous statement that DDT destroys boll weevils is made by Anon. (30, 56).

*Anthonomus pomorum* (L.), the apple blossom weevil

In England a proprietary spray material containing DDT (called De-Di-Tox) gave good results on 100 trees sprayed with 200 gallons of dilute spray at each application. Two applications gave as good results as three and a very large reduction of infestation was secured. This weevil is one of the hardest of all pests to control and this is the first time that such a good control has been recorded in this country, without any damage being caused to the trees.--Chambers and Hey (206).

*Anthonomus rubi* (Hbst.)

Gesarol powder in laboratory tests gave satisfactory control.--Denmark Statens Forsog. (225).

*Conotrachelus nenuphar* (Hbst.), the plum curculio

DDT seems to have little value in the control of this insect.--Porter (342).

*Pantomorus leucoloma* (Boh.), the white-fringed beetle

Preliminary experiments indicated that DDT is a very promising insecticide.--U. S. Bur. Ent. and Plant Quar. (388, p. 9).

DDT compositions were the most important insecticides ever tested against the white fringed beetle.--Geigy Co. (255).

*Sitona* spp., "sitones weevils"

DDT, both as spray and dust, appears particularly effective under laboratory conditions.--Chambers, Hey, and Smitt (207, 208).

*Sitophilus granaria* (L.), the granary weevil

Laboratory tests with DDT gave excellent kills.--Chambers, Hey, and Smitt (208).

*Sitophilus oryza* (L.), the rice weevil

In preliminary laboratory tests in Brazil, Gesarol P (containing 3 percent of DDT) was mixed with millet in the proportion of 1:1500, 1:3750, and 1:7500 by weight and then this mixture and weevils were put in small glass jars; all the weevils were dead within 185, 234, and 504 hours respectively. These tests were repeated by using five concentrations of undiluted DDT in talcum powder, and 100 percent

mortality was obtained as follows: 16 percent of DDT in 170 hours, 8 percent in 175 hours, 4 percent in 190 hours, 2 percent in 220 hours, and 1 percent in 260 hours. A satisfactory result was thus had by 1 percent of DDT in a proportion 1:5000 by weight of insecticide to millet. Feeding the treated millet to domestic animals showed that only high concentrations of the insecticide injured them. Many other tests were conducted on a commercial scale and it was concluded that millet can be preserved for at least 2 months by using 12 to 20 grams of Gesarol P per bag of 60 kilograms of seeds. In factories where the seeds are subject to washing processes much of the D.T. used against the weevils might be eliminated. In the use of 12 grams of Gesarol P per bag of millet seeds, about 0.36 gram of active ingredient was used in 60 kilograms of seeds.--Ienage and Giannotti (297).

Strangaliodes albosquamosus Boh.

DDT offers great promise for the control of this weevil, called the "capacho" of the vine in Chile. Vines sprayed with an emulsion containing DDT at 2 parts per 1000 were not damaged, and a 100 percent control was obtained of the insects that fed and walked on the treated plants. Death resulted within 3 or 4 days but apparently the insects were incapable of feeding and moving after the first day. A test with 1 percent of DDT in powder form gave no results as remarkable as did the application in liquid form.--Posenberg (352).

Dermestidae

Anthrenus scrophulariae (L.), the carpet beetle

Attagenus piceus (Oliv.), the black carpet beetle

According to Sameth, chairman of the National Pest Control Association's research projects committee: On carpet beetles no conclusions may be drawn as yet, since enough tests have not been made. However, one unit of a heavily infested apartment house was cleared up and immunized.--Anon. (150, 169).

Nontechnical reference

DDT will soon be a boon to thousands who in the past have suffered at the hands of buffalo moths [carpet beetles].--Anon. (22).

Nitulidae

Meligethes aeneus (F.), a rape beetle

Gesarol was put in porous bags, which were carried and shaken by men as they walked through a heavily infested field. Often 15 beetles were counted on a plant. About 2 to 3 kg. of powder were distributed per acre with excellent results.--Holst (282).

Beetles treated directly with Gesarol dust or those coming in contact with it on plants showed paralysis after several hours and died within 2 days.--Frey (246).

Gesarol powder at the rate of 20 kg. per hectare killed an average of 93.4 percent in 1 day and 77.2 percent in 2 days.--Denmark Statens Forsog. (225).

#### Ostomidae

##### Tenebroides mauritanicus (L.), the cadelle

Preliminary experiments indicated that DDT is very promising against insects attacking stored grains and packaged cereals. Several organic and inorganic dusts, including DDT, when added to wheat in extremely small percentages, were found to protect it from the cadelle and other stored-product insects.--U. S. Bur. Ent. and Plant Quar. (388, pp. 9, 11).

Radioactive bromine was used to prepare dibromodiphenyl trichloroethane, m.p. 139.0°-139.5°. A saturated solution of this compound in Cellosolve was applied to the posterior thoracic tergites of the larvae over a period of 8 hours and within 24 hours all the insects were torpid or dead. Radioautographs of dissected material showed the presence of the bromine homologue of DDT in the nerve cord and brain as well as in other parts of the treated insects.--Hansen et al. (373)

#### Scarabaeidae

##### Adoretus sinicus Burmeister, the Chinese rose beetle

In cage tests in Hawaii talc dusts containing from 0.25 to 3 percent of DDT and sprays containing from 2 ounces to 1 pound of DDT per 100 gallons gave good control. With the 3 percent dust mortality was 82 percent after 1 night's exposure and 100 percent after 3 night's exposure; 50 percent mortality was secured in approximately 11 hours. With a spray of 1 pound of active ingredient per 100 gallons, mortality was 65 percent after 1 night's exposure and 100 percent after 4 nights'; 50 percent mortality was secured in approximately 13 hours.--Holdaway and Nishida (281).

##### Popillia japonica Newm., the Japanese beetle

DDT and talc (1:9 by weight) were mixed with sifted sassafras sandy loam at the rates of 0.416, 1.04, and 2.08 grams of DDT per cubic foot, which was equivalent to incorporating 10, 25, and 50 pounds of DDT with the upper 3 inches of an acre of soil. At 60° F. the velocity of the poisoning of third-instar larvae was double that at 50° F.; it was tripled at 70° F., and quadrupled at 80° F. The velocity of poisoning with lead arsenate was found to increase in the same manner. The velocity of poisoning with 10 pounds of DDT per acre was not significantly different from that with 1,000 pounds of lead arsenate. The velocity with the 25-pound treatment was 28 percent faster and with the 50-pound treatment 76 percent faster than with 1,000 pounds of lead arsenate. DDT appears to be 100 times as toxic to the larvae in the soil as is lead arsenate.--Fleming and Maines (245).

In field tests against the adult beetles in 1943, 1/4 pound of DDT per 100 gallons afforded the same protection to peaches as a single application of the recommended derris-rosin residue emulsion spray, protecting both fruit and foliage for 2 weeks. A single application of another spray (1 lb. of DDT to 100 gal.) gave complete protection throughout the beetle-feeding season of more than 6 weeks. The spray left no visible residue on the fruit or foliage and caused no injury. DDT was effective at very low concentrations against the grubs in soil. In a number of soil types DDT, when freshly applied at 5 to 27 pounds per acre, was as effective as lead arsenate at the rate of 500 pounds per acre. Studies in the greenhouse indicated that relatively large quantities of DDT could be applied to the soil without detrimental effect on certain crops, but that beans, spinach, and tomatoes seemed to be unfavorably affected with applications of 25 pounds of DDT per acre.--U. S. Bur. Ent. and Plant Quar. (388, pp. 4-5).

Control of insects inhabiting the soil, such as the Japanese beetle grub and certain specific nematodes, has been encouraged by the results obtained with Gesapon containing DDT in a form assuring penetration of the soil sufficient to reach the pests.--Geigy Co. (255).

#### Nontechnical references

DDT is effective against Japanese beetles.--15, 28, 30, 32, 33, 40, 186.

#### Tenebrionidae

##### Tenebrio molitor L., the yellow mealworm

Same as under Tenebroides mauritanicus.--Hansen and coworkers (273).

#### Unidentified Coleoptera

DDT has been used successfully to destroy beetles.--Anon. (75).

#### LEPIDOPTERA

#### Aegeriidae

##### Sanninoidea exitiosa (Say), the peachtree borer

Five-year-old peach trees were sprayed on July 14, 1943, with a mixture of DDT, calcite, and fish glue at the rate of 1 pound of DDT to 100 gallons of water. On April 28 to 30, 1944, 10 of the 12 trees sprayed with DDT were found to have no borers and on the 2 remaining trees 10 live borers were recovered. Of the 24 untreated trees bordering the sprayed trees, 23 yielded live borers ranging from 1 to 16 per tree with an average of 6 live borers per tree; and 5 dead borers.--Driggers and Smith (232).

Crambidae

Crambus topiarius Zell., the cranberry girdler

Since this insect is active in the chaff on the floor of the cranberry bog, it may be practical to deposit the DDT on the chaff either before or after bloom in order to avoid injury to bees.--Doehlert (227).

Galleriidae

Galleria mellonella (L.), the wax moth

Same as Tenebroides mauritanicus (L.)--Hansen et al. (273).

Gelechiidae

Pectinophora gossypiella (Saund.), the pink bollworm

In preliminary tests in Louisiana, Texas, and Arizona, encouraging results were obtained with DDT.--U. S. Bur. Ent. and Plant Quar. (388, p. 19).

It can be controlled or eradicated if a complete coverage of DDT is placed on all cotton over the infested area and kept there by reapplications throughout the cotton-growing season. All chemicals have failed against the pink bollworm except DDT, which showed exceptionally well in all tests made.--McDonald (314).

Sitotroga cerealella (Oliv.), the Angoumois grain moth

All moths treated with DDT made violent movements and cast a number of legs, as described for Cheimatobia brumata.--Wiesmann and Fenjves (410).

Geometridae

Cheimatobia brumata (L.), the winter moth

Adults were put in petri dishes bearing a dry deposit of DDT. This was not powdery and so was not rubbed off the tarsi of the insect on to other parts of the body. All the treated moths made violent movements and cast a number of legs; they became paralyzed within a few hours and died within 48 hours.--Wiesmann and Fenjves (410).

Small-scale tests were carried out on plums and apples to compare DeDeTane (containing DDT) with lead arsenate. Comparison with unsprayed trees showed that both treatments had given good control.--Chambers, Hey, and Smitt (208).

Paleacrita vernata (Peck), the spring cankerworm

A few preliminary tests indicated that DDT at 2 ounces per 100 imperial gallons was more effective than lead arsenate at 5 pounds per 100 gallons. The spreader Orvus was used in all sprays at 8 ounces per 100 gallons.--Ross (354, p. 9).

Hesperiidae

Urbanus proteus (L.), the bean leaf roller

In Florida Gesarol was indicated as the only insecticide that gave complete control of both the bean leaf roller and the bean leaf hopper. Gesarol dust was applied 2 or 3 weeks before harvest and the residual effect lasted as long as the foliage remained green. A single application protected a crop for the most critical part of the season.  
--Geigy Co. (255).

Unidentified leaf rollers

In the tests on greenhouse crops DDT exhibited a strong toxicity to various leaf rollers.--Compton (212).

Hyponomeutidae

Plutella maculipennis (Curt.), the diamondback moth

In greenhouse tests with the DDT-talc-Orvus formula at 1 to 2 ounces of DDT per 100 imperial gallons, the kill approached 100 percent, and excellent plant protection was afforded by even lower strengths. When only the foliage was sprayed with DDT in a number of carriers it appeared that pyrophyllite was slightly better than talc or Friarite. Approximately four times as much DDT in talc-Orvus formulas were required to equal the kill by the acetone or Velsicol formulas. DDT retained almost its full toxicity on plant foliage for at least 15 days when the foliage was kept dry.--Ross (354, pp. 2-6)

In preliminary field tests DDT was very effective.--U. S. Bur. Ent. and Plant Quar. (388, p. 13).

Lymantriidae

Porthetria dispar (L.), the gypsy moth

Spectacular control of this moth was obtained through the aerial application of DDT. A 20-acre tract of infested woodland in Jefferson, Pa., was treated on May 3, 1944, with a concentrated spray at the rate of 5 pounds of DDT per acre. The spray settled through the forest as fine mist, which gave good coverage of exposed surfaces of trees, undergrowth, and the forest floor. Foliage was just beginning to appear and no eggs of the gypsy moth had hatched. After the spray had dried, a fine crystalline deposit of DDT remained on all exposed parts of the forest. The eggs hatched, but the small caterpillars were killed when they started crawling and came in contact with the DDT. No living larvae was found in the treated area. Another study of a 5-acre wood lot in New York, treated with DDT after foliage appeared and caterpillars were in different stages of development, indicated that this insecticide also kills the larger larvae of the gypsy moth. Other small-scale demonstrations with DDT as an emulsion, in aerosol form, and in a dilute spray mixture were conducted. All methods proved to be spectacularly effective against gypsy moths in all stages of larval development. It is believed

that, when available for the purpose, application of DDT by aircraft will afford a cheaper and much more effective method of control and eradication of gypsy moths than any method previously used.--U. S. Bur. Ent. and Plant Quar. (388, pp. 7, 8, 34); a popular account was written by E. F. R. (344); also by Anon. (112).

In the Cape Cod area of New England preliminary experiments using DDT in smoke were highly effective against gypsy moth caterpillars feeding on scrub oak. In one experiment in Pennsylvania, using aircraft spray of concentrated DDT, there was a complete kill of these caterpillars in 20 acres of timber at the rate of only 5 pounds of DDT to the acre, in contrast to 25 pounds of cryolite or calcium arsenate.--Annand (175, 176).

DDT is highly effective against the gypsy moth.--Anon. (47, 53, 74, 80).

#### Olethreutidae

##### Carpocapsa pomonella (L.), the codling moth

When tested by the apple-plug method DDT at 1/4 pound per 100 gallons killed 78 percent of the larvae and lead arsenate at 4 pounds per 100 gallons killed 54 percent, whereas a mixture of the two at these concentrations caused 100 percent mortality. In addition to this synergistic action, the mixture effects a more even distribution of DDT over the host plant and causes it to adhere better.--Siegler (364).

Tests with pure DDT (m.p. 108° C.) against the larvae by the apple-plug method showed neither wormy nor stung apple plugs. The DDT was applied at a concentration of 4 pounds to 100 gallons of 20 percent ethanol by volume. Di-p-anisyl and di-p-tolyl derivatives of 1-trichloroethane also had high toxicity, but other derivatives and also di-p-chloro and di-p-bromo derivatives of 1,1-dichloroethylene had low toxicity.--Siegler and Gertler (365).

In laboratory tests with DDT against newly hatched codling moth larvae, DDT in all forms except Gesarol A Spray gave very much better control than acid lead arsenate, the majority of the DDT mixtures giving better results at 1/4 pound than lead arsenate at 4 pounds. DDT ground in water with 3 percent of Orvus, gave consistently better results than any other mixture at all concentrations tested. At 1 pound per 100 imperial gallons it gave nearly complete control. As dry diluents for DDT, pyrophyllite appeared to be superior to talc or Frianite. Wettable sulfur, Coposil, and hydrated lime had no appreciable effect on the toxicity of DDT. Bordeaux reduced its toxicity decidedly. Summer-oil emulsion did not effect DDT alone or the DDT-Coposil combination, but it still further reduced the efficiency of the DDT-bordeaux. Against mature larvae DDT as a contact insecticide was effective only at very high concentrations in powders and solutions, but it is too ineffective to have any use in trunk sprays against hibernating larvae. Gesarol A Spray, containing 5 percent of DDT, was ineffective at 1 pound per 100 imperial gallons because of excessive run-off.--Ross (354, pp. 10-12).

DDT is much more effective than lead arsenate against recently hatched larvae, but it is less toxic than dinitrocresol and oil against mature larvae.--Ross (357).

At Vincennes, Ind., laboratory tests presented no evidence that wetting agents would improve the efficiency of any of the DDT formulas, and in many instances they tended to reduce the efficiency. DDT dissolved in soybean oil, benzene, ethylene dichloride, or xylene was much less effective than when used alone in a water suspension. After the tap-water sprays the DDT paste or pyrophyllite mixture gave better results when added to bentonite-soybean oil or petroleum oil emulsions than when used alone. Although a weak bordeaux can be used with DDT without seriously reducing its efficiency, the various forms of sulfur reduced the efficiency of deposits exposed to the tap-water sprays. DDT in combination with lead arsenate was most effective when the two were added to the spray mixture separately or ground with water to form a paste. The dry mixture was too granular. DDT promises to be a very effective fortifying agent for lead arsenate at dilutions as low as 2 ounces per 100 gallons. In two formulas it appeared to increase the deposits of arsenious oxide.--Steiner and coworkers (376).

DDT gave remarkable control in preliminary field tests at Vincennes, Ind., beginning late in July 1943. Three applications of 3 pounds of a 50:50 DDT-pyrophyllite mixture per 100 gallons, without supplements, stopped a heavy worm attack for the remainder of the season. Where this mixture was used at only 1 1/2 pounds per 100 gallons, the fruit averaged only 31 worms per 100 apples, as compared with about 100 worms following the lead arsenate program. Considerable defoliation occurred on trees of the Grimes variety, but this may have been caused by the abundance of mites. No defoliation occurred on Winesap trees.--U. S. Bur. Ent. and Plant Quar. (388, p. 2).

Preliminary tests in 1943 at Vincennes, Ind., showed DDT to be of considerable interest. A 50:50 mixture of DDT and Pyrax applied at 2 pounds per 100 gallons in the third and sixth cover sprays gave better control than any other treatments tried. It was resistant to weathering and remained effective for 26 days. Field tests indicated that the material is compatible with bordeaux and with mineral oil, but it did not show any toxicity to codling moth eggs.--Haeussler (269).

In 1944 DDT was tested in the field at five laboratories of the U. S. Bureau of Entomology and Plant Quarantine--Poughkeepsie, N. Y., Beltsville, Md., Kearneysville, W. Va., Vincennes, Ind., and Yakima, Wash. The material was used in a number of different ways. In all cases DDT gave much better codling moth control than lead arsenate. In many experiments 1 pound of DDT in 100 gallons was much more effective than 3 or 4 pounds of lead arsenate.--Porter (342).

In Virginia DDT was tested in four orchard plots of five trees each. DDT at 6.4 ounces in 100 gallons (Gesarol 2 pounds) in all seven cover sprays resulted in 7.1 percent of wormy apples and 8.6 percent of stings. At 12.8 ounces of DDT (Gesarol 2 pounds and Gesarol oil 1 gallon) in the last four cover sprays the results were 5.3 percent of wormy apples and 8.7 percent of stings.

A dosage of 1 pound of DDT in the third to seventh cover sprays resulted in 1.7 percent of wormy apples and 8.4 percent of stings. Lead arsenate at 3 pounds per 100 gal. in the complete schedule in three plots averaged 2.7 percent of wormy apples and 28.7 percent of stings. It was thus evident that DDT greatly reduced the percentage of stings in all plots, but at dosages below 1 pound of DDT the percentage of wormy apples increased. No spray injury on the three varieties of apple (Stayman-Winesap, Arkansas, and Delicious) was observed, and also no injury of fruit or foliage when bordeaux mixture was used with DDT. In laboratory tests the toxicity of DDT was not greatly altered by the addition of fungicides (wettable sulfur, Kolofof, flotation sulfur, bordeaux mixture, or Fermate), but 6 quarts of lime-sulfur or 83-percent summer-oil emulsion lowered its toxicity.

DDT (Gesarol AK 20 spray) used at the rate of 2 pounds per 100 gallons of spray, together with 1 pound of Fermate in the petal-fall and four cover sprays, was about four times more effective than a similar schedule of lead arsenates applied with flotation sulfur in the petal-fall and 2-4-100 bordeaux mixture in cover sprays. No injury resulted from the applications of DDT and Fermate.--Hough (283, 284).

Limited trials in Virginia indicated that Fermate combined with DDT offers great promise as a complete summer spray to control the apple scab and codling moth. In tests with DDT used in conjunction with bordeaux mixture, Tennessee Copper No. 26, or Fermate, DDT was somewhat more effective when used with Fermate than with the two copper fungicides. DDT applied in the calyx and four cover sprays was much more effective than the same number of lead arsenate applications.--Hurt (285).

Gesarol dry spray (20-percent DDT) used at the rate of 2 pounds per 100 gallons, in certain tests has given better results than lead arsenate used at the rate of 3 pounds per 100 gallons.--Geigy Co. (255).

#### Nontechnical references

DDT is effective against codling moth larvae.--5, 15, 24, 28. 32, 33, 35, 47, 48, 69, 75, 80, 144, 173, 188.

One observer figures that for codling moth alone there is a potential market of 15,000 tons of DDT insecticide a year.--Anon. (144).

#### Grapholita molesta (Busck), the oriental fruit moth

Very good results were obtained in treating the oriental fruit moth with Gesarol spray. The fruit (peach) injury has been reduced from 60 to 90 percent when compared with unsprayed trees.--Geigy Co. (255).

Nontechnical references

When DDT is used to control the oriental fruit moth, it also destroys insect parasites that are natural enemies of this moth.--Anon. (35, 48, 173).

DDT is toxic to the oriental fruit moth.--Anon. (28, 113).

Polychrosis viteana (Clemens), the grape berry moth

Gesarol was found effective against the grape berry moth.--Anon. (24).

Phalaenidae

Agrotis ypsilon (Rott.), the black cutworm

The larvae on tobacco were controlled by dusting or spraying the plants with Gesarol, or by watering with Gesapon.--Thomann (283).

In Switzerland effective treatments included Gesarol, applied as a dust or as a 2-percent spray. The dust adhered readily to tobacco leaves and was easier to apply, but the spray would probably be more effective on corn, as it would penetrate to the underground borings of the cutworm in the stem.--Thomann (384).

Alabama argillacea (Hbn.), the cotton leafworm

In preliminary tests in Louisiana, Texas, and Arizona, DDT was less effective than arsenical insecticides.--U. S. Bur. Ent. and Plant Quar. (388, p. 19); also Anon. (113).

Anticarsia gemmatalis (Hbn.), the velvetbean caterpillar

Preliminary experiments indicated that DDT is a very promising insecticide.--U. S. Bur. Ent. and Plant Quar. (388, p. 9).

Barathra brassicae

A dust containing 5 percent of DDT applied as a contact insecticide left 3 out of 12 larvae normal. When dusts containing 0.8, 0.4, and 0.2 percent of DDT were tested, as a stomach poison, 0.01 mg. per larva was fatal.--Martin et al. (319).

Heliothis armigera (Hbn.), the tomato fruitworm, the bollworm, the corn earworm

In preliminary field tests DDT was very effective against this species on tomatoes. Against the larvae DDT was the most effective insecticide tested against this pest.

In preliminary tests in Louisiana, Texas, and Arizona encouraging results were obtained with DDT against the bollworm on cotton.--U. S. Bur. Ent. and Plant Quar. (388, pp. 13, 14, 19).

DeDefane and DDT in proprietary emulsion form gave excellent control, equal, if not superior, to that given by lead arsenate. The caterpillars refused to feed on foliage sprayed with these preparations and died within 2 or 3 days; even very large caterpillars resistant to Derris or Lonchocarpus were easily killed. The emulsion, in addition, has the advantage of leaving no visible deposit.--Chambers, Hey, and Smitt (208).

In Florida DDT dust gave better control of corn earworms than DDT spray; as high as 95 percent wormfree ears on some plots. The materials were applied to the silks on sweet corn soon after they had developed.--Slawson (368, p. 125).

From 60 to 90 percent kill of corn earworms was obtained with the 2-percent Gesarol dust.--Geigy Co. (255).

#### Nontechnical references

DDT is effective against bollworms.--15, 32, 188.

DDT sprays and dust will knock out the tomato fruitworm.--(32).

#### Trichoplusia ni (Hbn.), the cabbage looper

In preliminary field tests DDT was very effective.--U. S. Bur. Ent. and Plant Quar. (388, p. 13).

#### Phaloniidae

#### Phalonia ambiguella (Hbn.), a European vine moth

Three spray materials, each containing 1 percent of bordeaux mixture, were tested in June 1942 for the control of the first-generation larvae. The percentages of infested bunches of grapes follow: 1 percent of Gesarol 8.2, 1 percent of Nirosan 9.6, 1 percent of lead arsenate 35.4, and untreated 55.3. In July three other spray mixtures, without the bordeaux, were tested and the following percentages of infested bunches of grapes resulted: 1 percent of Gesarol 2.4, 1 percent of Nirosan 2.4, 1.5 percent of Grapol 10.4, and untreated 43.4. The number of living larvae on 100 bunches of grapes follows in the same order: 3, 3, 11, 64.--Wiesmann (409).

#### Pieridae

#### Pieris brassicae (L.)

A dust containing 0.8 percent of DDT applied as a contact insecticide killed 60 percent in one test and all in another; a dust containing 0.4 percent DDT killed two thirds.--Martin et al. (319).

Same as for P. rapae.--Denmark Statens Forsog. (225).

Pieris rapae (L.), the imported cabbage worm

Gesarol powder in laboratory tests did not give satisfactory results.--Denmark Statens Forsog. (225).

A dust containing 0.8 percent of DDT was effective as a contact insecticide.--Martin et al. (319).

In preliminary field tests DDT was very effective.--U. S. Bur. Ent. and Plant Quar. (388, p. 13).

A Gesarol dust containing only 1 percent DDT was found to give good control of the three important cabbage worms. This is of great practical importance in that a single product can actually control these pests at the same time.--Geigy Co. (255).

Nontechnical references

DDT has been found effective against cabbage worms.--23, 32, 33, 75, 78; Warner (403).

Pyralididae

Pnlyctaenia rubigalis (Guenee), the celery leaf tier

In tests on greenhouse crops DDT exhibited superior toxicity to various leaf tiers.--Compton (212).

A Gesarol dust containing only 1 percent of DDT gave perfect results in Florida.--Geigy Co. (255).

In greenhouse tests a mixture of 10 parts of DDT, 87 parts of talc, and 3 parts of Orvus killed 100 percent of third- and fourth-instar larvae when applied at the rate of 1 ounce of DDT per 100 imperial gallons, and 40 percent when applied at one-eighth this dosage. In these tests, designed to determine combined contact and stomach action, the larvae were sprayed on paper and transferred to sprayed foliage while the spray deposit was still wet on both. Tested for stomach action only (unsprayed larvae placed on sprayed plants in pots or on leaves in jars) this same mixture killed 90 percent at the 1-ounce dosage and 60 percent at one-half that dosage. A suspension of DDT in water at the 1-ounce dosage killed 90 percent and at one-half this dosage ninety-five percent of the larvae. This suspension was made by pouring a solution of 10 grams of DDT, 10 ml. of Triton X-100, and acetone to make 100 ml. into water.--Ross (354, pp. 2-6, 15).

DDT in certain spray formulas is very effective.--Blauvelt (186).

Pyraustidae

Hellula undalis (F.), the cabbage webworm

In preliminary field tests DDT was very effective.--U. S. Bur. Ent. and Plant Quar. (388, p. 13).

Pyrausta nubilalis (Hbn.), the European corn borer

Preliminary experiments indicated that DDT is a very promising insecticide.--U. S. Bur. Ent. and Plant Quar. (388, p. 9)

A spray containing as little as 0.3 pound of DDT per 100 gallons, also a dust containing 2 percent of DDT, gave excellent results.--Geigy Co. (255).

Nontechnical references

DDT has been found effective against the European corn borer.--28, 32, 33, 186.

Sphingidae

Protoparce sexta (Johan.), the tobacco hornworm

Unsatisfactory or indifferent results were obtained with DDT.--U. S. Bur. Ent. and Plant Quar. (388, p. 13).

Tineidae

Tineola bisselliella (Hum.), the webbing clothes moth

Clothing, carpets, furs, and upholstered furniture can be protected by dusting them with Gesarol dust. The adult moths and newly hatched larvae are killed by contact with the material, although the eggs and older larvae are more resistant.--Stellwaag (377).

"Dow K 965, a product not yet on the market, together with DDT, seemed to be the best moth proofing agents, at least for the present."--Anon. (150).

Nontechnical references

DDT has been found effective against clothes moths.--Anon. (5, 9, 11, 13, 33, 55).

Tortricidae

Archips fumiferana (Clem.), the spruce budworm

Tests showed that this pest on fir, spruce, and pine trees in the central Rocky Mountain region can be effectively controlled by the application of DDT at the rate of 1 pound per 100 gallons of water. Previous attempts to control it by spraying with lead arsenate around camp grounds were only partially successful.--U. S. Bur. Ent. and Plant Quar. (388, p. 7).

Major experiments with DDT were carried out in the Rocky Mountain National Park and the Roosevelt National Forest of Colorado, where more than 40,000 acres have been attacked by this insect. In plots sprayed with DDT the larvae were killed when they came in contact with it.--Geiger (249).

Chemical control will probably become possible owing to improvements made in the use of the airplane for spraying forests from the air and to the discovery of DDT. During the summer of 1944 experiments were conducted to combat this insect in the Algonquin Park in Ontario. The sprays were applied from an American biplane which flew over the forest about 25 feet above the trees at 80 miles an hour. The results will not be known until next spring.--Daviault (222).

#### Nontechnical references

In Ontario the Department of Lands and Forests in May 1944 started using an autogyro to spray the forest with DDT to combat the destructive spruce budworm.--Anon. (39, 57). In Ontario DDT was proved more effective than nicotine or lead arsenate. A program was decided on involving spraying a solution of DDT from planes on heavily infested tests plots.--Breckenridge (189).

#### Archips rosaceana (Harr.), the oblique-banded leaf roller

In Oregon this pest attacks several cane berries, red raspberry being its favorite. DDT sprays and dusts were both tested. Dusts containing 1.5 to 3 percent of DDT gave almost 100 percent kill in all tests. The sprays contained 5 percent of DDT in an emulsible oil and also a prepared powder (Gesarol A-20). The DDT in oil at 1 and 2 quarts per 100 gallons of water and the Gesarol spray at 1 to 2 pounds per 100 gallons gave practically 100 percent control in all tests. The larger quantity of each material is recommended for control with one application 2 weeks before blossom time.--Schuh and coworkers (360).

One hundred pounds of DDT applied to 250 acres of seriously infested raspberries gave complete control. The application was made starting May 17 after the berries were in bloom.--Anon. (105).

In greenhouses 95 to 99 percent control with DDT compositions has been reported.--Geigy Co. (255).

#### Unidentified Lepidoptera

DDT kills moths.--(30, 32, 323).

Gesarol dust is used in gardens to control caterpillars.--Messerli (323).

#### HYMENOPTERA

##### Apidae

#### Apis mellifera L., the honeybee

Honeybees exposed for 30 minutes to glass plates covered with a dry film of DDT (10 micrograms per square inch) suffered approximately 100 percent mortality. This deposit was made by spraying DDT in water suspension at the rate of 1 pound per 100 gallons. The paralytic action on honeybees often is apparent after a few minutes' exposure.

The first symptoms are loss of control of the legs followed by paralysis of the hind legs and a rolling falling action. Death did not always occur following this paralytic action.--Filmer and Smith (241).

Bees confined in cylindrical wire-screen cages and fed a 50-percent honey solution lived for 10 days. The effect of DDT was tested in two ways: (1) Bunches of leaves and blossoms were sprayed and placed in the cages with the bees; (2) narrow strips of paper were sprayed and dried, then inserted as a collar inside the top of the cages. On the sprayed leaves and blossoms 16 and 8 ounces of DDT per 100 imperial gallons killed all the bees within 24 hours, while 4 ounces per 100 gallons killed very few even after 43 hours. Bees confined with the treated paper strips made no apparent effort to avoid the paper and all were killed within 20 hours by DDT at 4 ounces per 100 gallons.--Ross (354, p. 9).

Tests with DDT indicated that it may become a menace both to pollination and beekeeping. DDT was not repellent to bees. A 0.05-percent concentration of DDT fed in syrup to honeybees acted as a stomach poison. Contact with a 10-percent DDT dust proved fatal. Bees in contact with a surface sprayed with a 2-percent solution of DDT died within 6 hours. When brood and adult bees were sprayed with a 0.05-percent DDT solution, the unsealed brood was killed within a few hours, but the sealed brood and adults were unaffected.--U. S. Bur. Ent. and Plant Quar. (388, pp. 19-20).

A colony of bees located under the roof of a two-story house could not be eradicated by use of carbon disulfide or calcium cyanide, but 5 ounces of Gesarol A-20 Spray (20 percent of DDT) applied as a dust eradicated them after three weekly applications.--Wolfenbarger (415).

No damage was evident to honeybees working the blossoms on raspberries that had been treated with DDT (0.4 pound per acre) for the control of the oblique-banded leaf roller.--Anon. (105).

Gesarol spray is not harmful to bees, since it is applied to fruit trees in Switzerland only as a preblossom treatment and then again in June and July, while the bees are present in the trees only during the blossoming period. However, Gesarol dust cripples bees and may kill them if they become smeared with it.--Messerli (323).

Observations in DDT-sprayed apple orchards raise the question as to what DDT may do to honeybees and wild pollinating insects if the material should come into general use. In apple orchards, of course, the applications will not be made until the bees are through working in the apple bloom, but there might be an unfavorable effect on them because of the poisoning of the bloom of cover crops or weeds.--Porter (342).

Experiments have shown that dried Gesarol spray deposits cause no damage to bees. The Gesarol dust can be dangerous to bees, if they come in contact with the powder. Therefore, raspberries should not be dusted if the blossoms are open so that the dust falls into the flowers. Since the bees sit away from the blossoms, they do not come in contact with the Gesarol deposit. As a precautionary measure raspberries should be sprayed before they bloom, and of course fruit trees in blossom should not be sprayed with Gesarol.--Suter (380).

The effect of DDT on bees has been studied as a matter of importance in horticulture, and the position has not yet been clarified. It appears certain that bees are killed by direct Gesarol dusting and also by direct contact with Gesarol spray. On the other hand, contact with the dried spray film does not appear to affect them. The advice given, therefore, is to see that the fully opened blossom is not dusted and that spraying is done in the evenings or early mornings before the bees are about.--West and Campbell (406).

#### Braconidae

Ascogaster quadridentata Wesm., a parasite of the codling moth

Adults were placed in lantern globes resting on paper coated with the dry deposit from a spray of water-ground DDT (1 lb. per 100 imperial gal.). Moist cotton was supplied in a separate container in the globes. After approximately 17 to 22 hours, the mortality ranged from 87 to 100 percent.--Ross (354).

Macrocentrus ancylivorus Rohwer, a parasite of the oriental fruit moth

In laboratory tests all recently emerged adults exposed 12 hours to surfaces sprayed with DDT (1 lb. per 100 gal.) and allowed to dry were killed. In view of the habits of these parasites, such a contact with the material in peach orchards is very likely.--Smith and Driggers (370).

Same as for Ascogaster quadridentata.--Ross (354).

#### Formicidae

The effectiveness of DDT against the "Sauva" ant in Brazil has not been established.--Anon. (146).

According to Sameth, chairman of the Research Projects Committee of the National Pest Control Association, DDT was not successful in ant control.--Anon. (150, 169).

Gesarol dust is often used to destroy ants in beehives and should be so placed that the bees will not come in contact with it.--Messerli (323).

#### Nontechnical references

DDT is a poison to insects, such as ants, that crawl on surfaces impregnated with it.--Anon. (18, 27, 40).

Ichneumonidae

Ephialtes caudatus (Ratz.), a parasite of the codling moth

Same as for Ascogaster quadridentata.--Ross (354).

Tenthredinidae

Neodiprion abietis (Harr.), the spruce sawfly

In Ontario DDT was proved more effective than nicotine or lead arsenate, and a program involving spraying a solution of DDT from planes on heavily infested test plots was decided on.--Breckenridge (189).

Hoplocampa testudinea (Klug), the apple sawfly

DeDeTane (containing DDT) was applied in mixed sprays at two centers. Other insecticides were also tested. Nicotine gave the best control, while DeDeTane was not very effective.--Chambers, Hey, and Smitt (208).

Athalia spinarum (F.)

Gesarol powder in laboratory tests gave satisfactory control.--Denmark Statens Forsog. (225).

DIPTERA

Culicidae

Aedes pseudoscutellaris (Theob.)

Aedes vexans (Mg.)

In Fiji a 5-percent solution of DDT in mineral oil was tested in trays, tubs, and in swampy areas containing larvae of these species of mosquitoes. It was concluded that DDT is suitable as a mosquito larvicide in Fiji with an annual rainfall of 120 inches and a humidity of 74 to 84 percent. One quart of oil plus DDT will usually be as effective as 10 to 14 gallons of oil alone.--Lever (303).

Anopheles albitalis Arribalzaga

Anopheles argyritarsis Robineau-Desvoidy

Anopheles noroestensis Galvao and Lane

Anopheles strobdei Root

Anopheles triannulatus (Neiva and Pinto)

In Brazil various concentrations of DDT were tested against larvae of these anophelines. In aquaria or tanks containing 1 part of DDT to 1000 parts of water the larvae died in less than 5 minutes, while in tanks containing 1 part of DDT to 60 million parts of water more than 36 hours were required for larval mortality. DDT retained

its larvicidal effect in tanks for 4 months. In the dilutions used DDT did not kill the eggs and did not prevent egg laying, but the larvae died immediately after hatching.--Wasicky and Unti (404).

Anopheles quadrimaculatus Say, the common malaria mosquito

In laboratory tests a dust of the solid solution of 1 part of DDT and 4 parts of stearic acid, and another dust of DDT mixed mechanically with talc were applied at the rate of 1/2 pound of active ingredient per acre. The solid solution withstood 20 to 23 artificial rains and was effective in killing larvae for 41 to 44 days. The DDT-talc dust withstood only 14 to 16 rains and killed larvae for only 26 to 30 days. In tests made in a natural anopheline breeding place, the water was dusted at the rate of 1 pound of DDT per acre. Treatments with the solid solution were effective for 35 to 44 days in killing larvae being subjected to 8.63 inches of rain, while the DDT-talc mixture lasted only 7 to 35 days under an average of only 4.33 inches of rain. Other tests in a natural breeding environment showed that the solid solution continued to kill larvae for 43 days, while the DDT alone killed for only 18 days.--Deonier and Jones (226).

Anopheles superpictus Grassi

Neocid was an effective control for adults and larvae, but its effect on the pupae and eggs was insignificant. Against the larvae it attained the greatest effect of all known control agents. After the roof and walls of cow stables had been sprayed with 1 gram of Neocid (0.05 gram of DDT) per square meter, Anopheles were absent for a period of 1 to 5 weeks. By use of mixtures containing 2 percent of Neocid in petroleum, good control of larvae was obtained in clean water with 0.15 gram of Neocid per square meter of water surface.--Mandekos (317)

Anopheles spp.

DDT was completely effective against anopheline larvae for several days when applied at the rate of 0.1 pound per acre of water surface.--Stage (373, p. 94).

It has been stated that the campaign in Burma has been made possible through the control of mosquitoes with DDT. This in turn has largely prevented the troops from being infected with malaria.--Hey (279).

In both the Pacific and Mediterranean areas the malaria-carrying mosquito was the greatest insect foe with which the troops had to contend, and it was against this that DDT would find its greatest use. The application of small quantities of DDT in oil to the breeding sites of anopheline mosquitoes killed all the larvae.--Anon. (142).

DDT was employed July 1944 for large-scale airplane spraying experiments in malaria control in Agro Romano, Italy. The DDT is thought to have killed not only larvae but mosquitoes in farm buildings.--McCormick (312).

Recently the U. S. Public Health Service tried DDT against malaria-bearing mosquitoes in Arkansas. In a 36-square-mile area of cotton country near Helena, it hired high-school boys to spray the walls of nearly all the sharecroppers' shacks. Cost: 74 cents per house for DDT and labor. Results: A 94-percent reduction (for at least 2 months) in the number of mosquitoes in the treated houses. The job used an average of 0.82 gallon per house of 5-percent DDT solution. Per house it consumed 10 minutes, took 0.73 man-hour, and cost 74 cents for material and labor.--Anon. (164).

As soon as more DDT is available for civilians, a nationwide spraying program will begin, to guard against infection from homecoming malarial servicemen.--Anon. (162).

DDT is more toxic to mosquito larvae than any substance heretofore known. Consequently, it can be used in small amounts with resultant saving of time and effort in larvicing operations. The application for malaria control which is most promising, however, is its use in spraying the habitations of native carriers. When DDT in kerosene solution is sprayed on interior surfaces, a residue is left which will kill insects lighting on the treated areas for several months. Since the destruction of infected adult mosquitoes constitutes the most effective break in the chain of transmission of malaria, this material offers great promise for control of the disease in many tropical regions where it has been a principal cause of poor health and poverty.--McCoy (313); abstracted by Anon. (103, 128).

#### Chaoborus punctipennis (Say)

DDT was tested in the laboratory against the larvae and pupae by a method similar to that used in testing culicine larvicides. DDT was almost as toxic as pyrethrum. It was lethal to larvae at 1 part in 75 million parts of water, while about twice this concentration was required to kill all pupae. With median lethal concentrations 3 or 4 hours elapsed before the larvae became affected, while toxic dosages of pyrethrum produced almost immediate effects.--Lindquist and Bushland (308).

#### Culex annulirostris Skuse

(Culex fatigans) = Culex quinquefasciatus (Say)

Same as for Aedes spp. (Lever, 303).

#### Culex pipiens L., the northern house mosquito

All the treated mosquitoes made violent movements and cast a number of legs, as described for Cheimatobia brumata. They became paralyzed in a few hours, and died within 12 hours.--Wiesmann and Fenjves (410).

#### Culex quinquefasciatus Say, the southern house mosquito

In Brazil various concentrations of DDT were tested against larvae of this species kept in aquaria under conditions similar to those found in nature. It was shown that DDT is highly effective even in weak

concentrations, the concentration recommended being 1 gram to 25,000 liters of water. This concentration would not be dangerous or objectionable to domestic animals or man. DDT as a mosquito larvicide has the following advantages. It has a high lethal effect upon all larval forms of Culicinae and Anophelinae tested. Its larvicidal power persists up to 130 days, even in very weak concentrations, thus favoring its use in natural breeding places. It impedes potential breeding places from becoming receptacles of active larvae, although it does not act as a repellent since the females deposit their eggs on water treated with this chemical. It eliminates an entire life cycle of mosquitoes in less than 2 hours in a concentration of 1 gram per 10,000 liters, in less than 8 hours in 1 gram per 20,000 liters, and in less than 50 hours in 1 gram per 60,000 liters of water.--Wasicky and Unti (404).

**Culex tarsalis** Coquillett

In the laboratory suspensions of DDT made by adding an alcoholic solution to water gave the following results (dilutions by weight):

A corner of a drain (6 sq. ft. and 3 in. deep) containing over 300 larvae and 100 pupae was treated with DDT to give a dilution of about 1 to 100,000,000 parts of water; at the end of 26 hours 1 larva and 6 pupae were still alive. In other tests the residual effect of DDT was appreciable. Small glass jars containing a 1 to 1,000,000 dilution of DDT were emptied and then refilled with fresh clean water containing larvae and pupae. The next morning all larvae and pupae were dead. The jars were again emptied and refilled, with the same result. Adult mosquitoes that alight upon surfaces sprayed with this insecticide are killed. Dissolved in an appropriate solvent and sprayed on walls and ceilings, it remains effective for several weeks, all mosquitoes resting upon the sprayed surfaces dying after a few minutes' contact.--Herms and Gray (276).

*Culex* sp.

Same as for Anopheles superpictus (Mandekos 317) and Culex quinquefasciatus (Wasicky and Unti 404).

DDT gave amazing kills of culicine larvae when used at the rate of 1 part to 100 million parts of water.--Stage (373).

#### Unidentified mosquitoes

As a larvicide DDT may be substituted for paris green in dusts, diluted 1 part with about 4 parts of powdered talc, or with equal parts of calcium stearate. Approximately the same quantity is used as with paris green (1/2 to 2 lbs. per acre of active ingredient), but its effects apparently are more lasting. It can also be dissolved in acetone, and then dispersed in water and sprayed; applied in this manner it appears to be several times more toxic than phenothiazine. Dissolved in kerosene or petroleum distillate (2.5 percent solution), it is highly effective as a larvicide when applied at the rate of 0.1 pound of Gesarol [DDT is meant] per acre. It can also be dissolved in various solvents, such as alcohols or Cellosolve (ethylene glycol monoethyl ether), and applied to water.--Herms and Gray (276).

DDT in heavy oil solution is used in the Army for spraying on water or in light-oil solution for spraying on walls and furniture. It is as effective against mosquitoes as it is against lice.--War Department (395); Anon. (129).

An entire Pacific island of 6400 acres was sprayed with DDT from a torpedo bomber, which flew at 125 miles an hour at an altitude of 150 feet, spraying 10 gallons of the DDT-oil solution per minute. It was estimated that 2 quarts of the solution was sufficient to cover an acre. The DDT was also used in great quantities on more than 7,000 corpses, and around mess halls and latrines, for it is said to kill every insect on contact.--Wilson and Kelly (411); abstracted by Anon. (139, 163).

Saipan was dusted with DDT from an airplane to combat a dengue type of mosquito. Afterwards not a mosquito or fly was to be seen, and within a few weeks dengue had practically ceased to bother the medical service.--Anon. (154).

Tests by the Alameda County (Calif.) Mosquito Abatement District indicate that DDT is the most potent and effective larvicide and culicide known.--Anon. (19).

#### Nontechnical references

DDT is toxic to mosquitoes.--12, 26, 27, 30, 33, 40, 44, 68, 75, 76, 84, 88, 121, 142, 161, 188.

DDT has already achieved marvelous results sprayed from airplanes in northern Alberta to free large areas along the Alaska highway from mosquitoes.--39, 57.

DDT in solution applied from an airplane at the rate of 5 pounds per acre killed all the mosquitoes in the test plot.--Anon. (53, 74, 112); E. F. R. (344).

Itonididae

Diarthronomyia hypogaea (Loew), the chrysanthemum gall midge

DDT had no apparent effect on the larvae and pupae within the galls, or on egg laying by the adults.--Ross (354, p. 8).

Muscidae

Musca domestica L., the housefly

Filter paper soaked in solutions of DDT in acetone varying from 0.125 to 16 percent in concentration was dried for 48 hours and then put in petri dishes with flies. After 20 minutes the insects were partially paralyzed, and all died practically at the same time regardless of the concentration of DDT.--Lepage and Giannotti (297).

A fly was confined under a tumbler resting on paper, a 2-inch spot of which was sprayed lightly with a DDT solution. After 8 minutes the fly showed effects of the DDT picked up on its feet, and after 42 minutes the fly was dead.--Woodbury (418).

Tests were made at the Delaware Agricultural Experiment Station in the summer of 1944 to determine the value of DDT in controlling the housefly. Two pens were cleaned and painted with white cold-water casein paint. The walls and ceiling of one pen were sprayed with a 2 percent solution of DDT in deodorized kerosene, while the second pen was left untreated. Both pens were then filled with birds and periodic observations were made on the abundance of flies in each pen and the prevalence of fly specks on the walls and ceilings. Examinations consistently showed a striking reduction in number of flies in the treated pen as compared with the untreated pen. Six weeks after treatment, 22 flies were counted on the ceiling of the treated pen, as compared to 380 on the untreated pen. The walls and ceiling of the killing room were also sprayed with 2 percent of DDT in deodorized kerosene. Large numbers of flies observed on the ceiling when the building was closed for the night were all dead on the floor in the morning. A month after the room was sprayed with DDT, 100 percent kills were still being secured when flies were confined to this room overnight.--Wolfenbarger and Hoffmann (416).

Dr. Victor Froelicher, of Geigy's New York research staff, said there's no evidence yet that DDT is a fly repellent. He sprayed a strip of DDT on a table, and watched its effect. A fly walked across the table and back again, crossing the DDT area without hesitation. Soon it began to dart across the room like an arrow. When it alighted, it began to clean its legs in typical fly fashion--and to find that it had navigating trouble. Its front legs were affected first, but flying wasn't disturbed immediately. Then, after several minutes, all legs were paralyzed and the fly fell on its back, but showed signs of life until the next day. Dr. Froelicher calculated how much DDT it takes to kill a fly. On 1 sq. cm. the amount, he figures, would be 0.00001 microgram. For killing flies some producers think a combination of DDT and pyrethrum may be better than either one alone.--Anon. (144).

The common housefly in this country and similar species in the Tropics which carried dysentery and other diseases were readily killed by a pyrethrum-DDT spray.--Anon. (142).

An AA-grade fly spray can be prepared with 1 gram of DDT in 100 ml. of base oil. This gives a kill of 95 to 99 percent, but the knock-down may be slow, and more than 24 hours may be necessary for the full killing effect to be developed.--Cameron (194).

DDT sprayed on walls or screens remains effective against houseflies for as long as 3 months.--Anon. (158); USDA (389).

It is probable that DDT may be used in fly sprays in combination with pyrethrum to effect economy and to increase the duration of the lethal efficacy.--Campbell and West (202).

In laboratory experiments plywood was cut to fit inside zinc-mesh fly cages. One had plywood painted with DDT (5 percent) paint covering the floor, half way up the sides and two thirds of the lid, and a second cage was covered with an identical area of plywood painted with the same paint without DDT. One hundred housefly pupae in a crystal-lizing dish were placed in each cage together with containers of sugar and water, and the cages were inspected daily. The oil-bound water-paint containing DDT was effective against houseflies, and tests carried out after 2 months showed that the paint had not lost its insecticidal properties. Small rooms were then painted with a DDT paint, and by a fortuitous mistake this paint used contained only 0.5 percent of DDT--exactly one-tenth the amount used in the laboratory experiments. It was then found that 90 percent kills of houseflies were obtained overnight as compared with negligible kills in an identical room painted with the same paint containing no DDT. Preliminary observations indicate that the flies tended to avoid contact with the DDT-painted surface. There is already evidence that in certain continuous film-forming media DDT retains its insecticidal effect. The results now being obtained in a factory canteen painted with this DDT oil-bound water-paint are fully supporting the results obtained in the laboratory and laboratory-field experiments.--Campbell and West (201).

DDT in oil paint and enamel, however, did not prove insecticidal to flies at all. The oil-bound water paint lost none of its effectiveness after two months, and was only very slightly less effective after six months. There is evidence that DDT is effective in a coumarone resin film, and in a wax floor polish, both instances of DDT being enclosed in a continuous film, so that there would appear to be good prospects of successful formulation in the more decorative and durable paints.--Campbell and West (204).

#### Nontechnical references

DDT is effective against flies. 5, 7, 8, 15, 18, 22, 23, 26, 27, 28, 30, 33, 40, 42, 51, 55, 57, 75, 78, 79, 80, 90, 102, 141, 186, 188, 194.

### Siphona irritans (L.), the horn fly

Sprays with DDT greatly reduced populations of this fly attacking beef cattle under ranch conditions as well as the number of severe injuries caused by bites of these flies. A spray containing 1 percent of DDT killed all horn flies that alighted on the treated animals for 1 week. Range cattle sprayed with  $\frac{2}{3}$  pint per animal of a 0.2-percent DDT emulsion remained almost entirely free from flies for 7 days.--U. S. Bur. Ent. and Plant Quar. (388, p. 22).

#### Nontechnical references

DDT compositions gave satisfactory control of the horn fly in Texas.--Anon. (55).

### Stomoxys calcitrans (L.), the stablefly

In Sweden Gesarol M proved effective in control of the flies in cow stables and pigsties. One can of Gesarol M was added to 40 liters of water and the suspension applied with a pressure garden sprayer, at the rate of 1 liter per 4.5 square meters. One spraying usually lasted for 3 weeks in warm weather and 5 or 6 weeks when the temperature was low. In Denmark, when whitewash containing 3 percent of Gesarol was used to paint the interior of stables, the effect lasted longer than when Gesarol alone was sprayed on the walls and ceiling.--Jarl (287).

A dairy barn in Florida was sprayed with DDT, and 10 days afterwards flies were still dying as a result.--Watson (405).

#### Oestridae

### Hypoderma bovis (Deg.), the northern cattle grub

### Hypoderma lineatum (De Vil.), the common cattle grub

Dusts containing 10 percent of DDT were almost entirely ineffective against cattle grubs.--U. S. Bur. Ent. and Plant Quar. (388, p. 22).

Twelve grams of a mixture composed of DDT 20 percent, wettable sulfur 34 percent, wetting agent 7.6 percent, and inert filler 38.4 percent was suspended in 500 cc. of water. Six cows moderately heavily infested with oxwarbles were selected, and 10 cc. of this mixture was introduced into the opening over each grub by means of a syringe having the needle removed. Upon inspection 3 days later none of the treated grubs were killed.--Stewart (379).

#### Nontechnical reference

Dairy and beef cattle plagued by heel flies [adults of cattle grubs] have been quieted by sprayings of Gesarol.--Anon. (55).

Sespidae

Themira putris (L.)

Tests with poultry manure showed that DDT may be of considerable value as a larvicide. When the manure under wire sun porches for turkeys was sprayed with solutions of DDT, phenothiazine, thiourea, and borax to control the development of fly larvae, DDT was equal to phenothiazine and superior to the other materials tested. Larvae in DDT-treated manure rose to the surface and perished in large numbers. Treatment with DDT reduced the number of flies emerging by 90 percent. --Wolfenbarger and Hoffmann (416).

Simuliidae

Simulium spp., black flies

A 20-acre tract of woodland in Jefferson, Pa., was treated with a concentrated spray of DDT at the rate of 5 pounds of DDT per acre. The purpose was to kill the gypsy moth caterpillars, but all black flies were eliminated from the area for at least a month after treatment. --U. S. Bur. Ent. and Plant Quar. (388, p. 8); also E. F. R. (344) and Anon. (53, 74, 112).

Trypetidae

Anastrepha ludens (Loew), the Mexican fruitfly

In Mexico preliminary studies with DDT in dusts and oil preparations showed promise in preventing fruit infestation. --U. S. Bur. Ent. and Plant Quar. (388, p. 6).

Rhagoletis pomonella (Walsh), the apple maggot

In laboratory tests with several new insecticides DDT appeared to be the most promising. Cage tests with DDT sprays and dusts indicated that the dust kills very rapidly at comparatively low concentrations (1.5 to 5 percent). The sprays were relatively ineffective. Exposure of DDT under an ultraviolet sun lamp did not destroy its effectiveness as a dust. --Garman and Townsend (248).

A 3-percent Gesarol dust showed excellent promise against the apple maggot. --Geigy Co. (255).

Rhagoletis sp., cherry fruit fly

In 1939 Gesarol was found effective against this fly. --Anon. (24).

SIPHONAPTERA

Pulicidae

Ctenocephalides canis (Curt.), the dog flea

C. felis (Bouche), the cat flea

DDT is deadly to such common household pests as dog's fleas.--  
Anon. (27, 30, 32, 33, 55, 75, 141).

A single application of Neocid containing 5 percent of DDT to dogs has remained effective for over 6 months of daily brushing and constant exposure to reinestation. Washing might remove enough of the material to require another treatment.--Cameron (194).

Dr. Thienes and his associate, Homer C. Lawson, dusted their Siamese cat and three kittens, a Persian cat, and a dog with DDT six times in 4 months. The amount applied to the cats and dogs controlled the fleas for 10 days and did not produce any symptoms of poisoning.--Cox (216).

ACARINA

Argasidae

Ornithodoros megnini (Duges), the ear tick

With a nondrying adhesive containing DDT it was possible to protect the ears of cattle, sheep, and goats from this tick for 90 to 120 days. The spraying of salt troughs and the areas under them with equal parts of kerosene and used motor oil also destroyed many of these ticks. When both these treatments were used, marked reductions of tick populations in pastures were observed.--U. S. Bur. Ent. and Plant Quar. (388, pp. 22-23).

Ornithodoros moubata (Murray), the argasid tick

DDT in Shell Oil P31 or in Shell Odorless Distillate (1:19) killed 10 percent of the third-instar nymphs only at a dosage of 0.37 mg. per square centimeter. DDT undiluted killed 10 percent after 3 days and 40 percent after 6 days.--Robinson (350).

Eriophyidae

Eriophyes sheldoni (Ewing), the citrus bud mite

Field tests of DDT for control of this mite have not been encouraging.--Calif. Fruit Growers Exchange (192).

Citrus bud mites were successfully controlled with different combinations of Gesarol dusts or sprays.--Geigy Co. (255).

Ixodidae

Amblyomma maculatum Koch, the Gulf Coast tick

In preliminary field tests 5 percent of DDT in nondrying adhesives gave protection from reinestation for 3 to 5 weeks, whereas the materials now in use by ranchmen did not give protection for more than 8 days.--U. S. Bur. Ent. and Plant Quar. (388, p. 23).

Dermacentor albipictus (Pack.), the winter tick

Investigations on control were concerned principally with washes that would kill all stages of this tick and protect horses against reinestation. Considerable progress was made toward the development of a wash consisting of DDT and soluble pine oil in water.--U. S. Bur. Ent. and Plant Quar. (388, p. 22).

Dermacentor variabilis (Say), the American dog tick, also the common wood tick

Experiments in killing wood ticks were less promising than in killing the spruce budmoth in Colorado. Forest rangers dusted with DDT said the ticks were slower in attacking them, but several days were required for the chemical to kill the ticks.--Geiger (249).

For killing ticks about the premises of camps, playgrounds, parks, kennels, and residences, a spray containing 5 percent of DDT was effective. An emulsion of this material caused no injury to the vegetation, and when applied at the rate of 1 pound of DDT per acre it gave control of the ticks for about 6 weeks.--U. S. Bur. Ent. and Plant Quar. (388, p. 21).

Rhipicephalus sanguineus (Latr.), the brown dog tick

According to Sameth, chairman of the National Pest Control Association Technical Committee, for brown dog tick control DDT was "100 percent superior to anything used in the business before."--Anon. (150, 169).

Nontechnical references

DDT will be a boon to thousands who have suffered from ticks.--22.

Ixodes ricinus scapularis (Say), the black-legged tick

Same as for Dermacentor variabilis.--U. S. Bur. Ent. and Plant Quar. (388, p. 21).

Tetranychidae

Paratetranychus citri (McGregor), the citrus red mite

Laboratory tests using dusts, water suspensions, and oil containing DDT were ineffective. Field observations on citrus trees which have

had DDT treatments and ~~had~~ no control and that frequently the red spider population is greater than after other treatments.--Calif. Fruit Growers Exchange (1951).

#### Paratetranychus pilosus (C. and F.), the European red mite

In Vincennes, Ind., apple trees sprayed with a 50:50 mixture of DDT and Pyrax three times at 3 pounds per 100 gallons had a substantial build-up of this mite and its ladybird predators were entirely absent on these trees. The predators appeared to hold the mites in check on other trees in the same block on which the usual insecticide materials were used.--Haeussler (26), U. S. Bur. Ent. and Plant Quar. (388, p. 2).

In a large proportion of the experiments in apple orchards the mites in the East and Northwest have become excessively abundant in trees sprayed with DDT. The foliage on these trees was in poor condition--bronzed, with extensive dead or dry areas, and often with severe defoliation. Most of this condition is attributed to excessive mite populations, but some of it may have been caused directly by the DDT. With this possible exception, the danger of injury to fruit trees does not appear serious.--Porter (342).

DDT may kill off the parasitic and other enemies of an insect pest without hurting the pest itself. This has already happened in New Jersey in the case of European red mite, which has increased destructively in certain spots sprayed with DDT while on adjacent plants there were either few or no mites noticeable.--Doehlert (227).

#### Tetranychus pacificus (McG.), the Pacific mite

Same as for Paratetranychus pilosus.--Porter (342).

#### Tetranychus spp., common red spiders

In England DDT used alone has failed to control the red spider on fruit trees and vine ~~and~~ ~~and~~, but a good control can be obtained if the DDT is incorporated in an oil spray.--Hey (278, 279).

In Ontario DDT at rates up to 1 1/2 pounds per 100 imperial gallons (both dry spray formulas and in Velsicol) caused no appreciable kill of any stage.--Ross (354, p. 9).

DDT is apparently of little or no value for the control of mites such as red spider.--Ross (357).

Unsatisfactory or indifferent results were obtained with DDT.--U. S. Bur. Ent. and Plant Quar. (388, p. 13).

In experiments to control the codling moth in Virginia, mites increased greatly on all ~~free~~ trees treated with DDT, averaging 250 mites per 100 leaves compared to 2 per 100 leaves on trees treated with the usual arsenical sprays.--Hough (284).

Although extremely effective against the codling moth, DDT is apparently without action on the red spider, which so often accompanies the codling moth and which if unchecked, might be a serious menace to fruit crops.--Anon. (35, 48, 69).

Nontechnical references

DDT compositions have given poor results against the red spider.  
--32, 55, 102, 113, 173, 186, 212.

Trombidiidae

Nontechnical references

DDT will be a boon to thousands who have suffered from chiggers.  
--22.

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